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Motivating Plant Management Planning and Control

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Prepared monthly oral cost presentations at an hour's morning meeting for each of seven operating units—preparation is done concurrently with closings, not subsequent to them—supplies accounting interpretations to responsible line personnel, in the procedure here described, which is built on forthright acceptance of the industrial accountant's responsibility, not only to inform operating men of conditions needing attention if profit is not to suffer but also to stimualte solutions. Included in the article are suggestions for the successful conduct of such meetings.

A COMMON COMPLAINT of plant accountants is that their reports are not used effectively by the plant manager. Admittedly, it is discouraging to spend the time and effort required to inform management of progress against a projected program, to document the reasons for success or failure and to suggest decisions for actions leading to cost improvement, only to find that these tools are not put to use. The plant manager today is subject to many pressures, such as community relations, labor negotiations and quality research which, though peripheral to his main responsibility, tend to absorb an important part of his daily schedule. As a result, the accountant finds it difficult to obtain an audience for discussion of the significance of his reports on a face-to-face basis and in an objective fashion with the man who is empowered to make decisions and to take the indicated actions.

In the Armstrong Cork Company we had wrestled with this problem over a period of time. Some years ago, we made it the major subject of discussion in an accounting conference. As a result, we developed a plan which has not only removed the frustrations suffered by our plant accounting staffs but, more impor-

tantly, has been accepted by our plant managers as one of their most valuable techniques. Through actual experience, we have learned that the plan, properly administered, results in the stimulation and motivation of plant management toward sound decision and prompt action and has provided marked improvement in factory cost trends. In the belief that our solution may be of assistance to other accounting organizations, we are presenting this case study.

Armstrong operates 19 domestic plants. Each plant has its individual manager who is assisted by a staff consisting of the plant accountant, the industrial engineer, the laboratory supervisor, the production control supervisor and, in addition, plant supervisors and foremen. Production costs are the complete responsibility of the plant manager, who answers directly to a divisional manager in charge of both sales and production. The basic guide available to the plant manager in discharging this responsibility for costs is the monthly report indicating what has actually transpired against what was budgeted to have happened.

Prerequisites of the Motivation Program

We have found that there are two keys to directing managerial effort into productive channels. One is the interpretation of the accounting results and the other an effective presentation of this information. Before we can meet these two requirements, it is necessary that certain conditions prevail within the plant. First, the members of the accounting staff must be capable technically. You may say that is a fairly safe assumption to make. However, there are cases where this may not be true. We should stop occasionally and take an objective look at current performance to see whether we are keeping abreast of the new developments which are being presented by accounting literature every day. Does the staff take advantage of opportunities for further education and training, not just in the statistical aspects of accounting, but also in the broader fields of economics and management? Second, the accounting staff must be capable of meeting its full responsibility. To be confident that this is true, it is necessary to spend a great deal of time in the selection and training of people to assure having an intelligent and conscientious group made up of individuals who will have a keen sense of stewardship in their jobs. Third, we must have standards and budgets which are well engineered, the composition of which are understood. They must be in sufficient detail that the analysts may know exactly what is in them and why it was put there. Fourth and most importantly, we must have an intelligent and capable management group which recognizes the importance of cost control and cost reduction.

To reiterate, the background requirements for the plan under discussion consists of a plant controller who is technically capable of understanding and interpreting cost figures, an accounting organization which can be relied upon to pull figures together quickly and accurately, well-engineered standards and budgets which provide a yardstick, and, finally, a plant manager who not only wants to do a good job but a better one. With these four prerequisites, we are in a position to make a sound interpretation of monthly results and to make a presentation of the information in such fashion that constructive action will be taken. We can place the emphasis where we feel it is needed, and, depending upon the degree to which we are successful, we can actually stimulate the plant management group into actions which will be effective both in its day-to-day control of production costs as well as in its planning for the future.

The development of the technique of motivating the management group in our plants is not something which we can afford to be complacent about. This quality is a necessary part of the controller function. To simply accumulate data and turn them over to someone else for their interpretation, or misinterpretation, as is often the case, can frequently result in decisions and actions which will prove to be both unsound and costly. This may have been accepted as the function of the accountant or controller fifteen to twenty years ago. Today's plant controller has a much greater obligation to management. The problems of running a business seem to have increased in geometrical progression during the past two or three decades. Plant managers are busier people and are more and more coming to realize the need for relying upon their cost specialists for guidance and recommendations as to what they must do to keep production costs in line. Plant managers are capable men. They have been chosen for their job because of their proven ability. Their objective is not just to maintain the status quo in their plants but to make their plants more productive and more profitable. They want suggestions as to where they should direct their efforts in order to accomplish this. In brief, they are anxious for our opinions and recommendations as to what must be done to correct unfavorable situations and to improve the favorable ones. This is a responsibility we cannot ignore.

Appointment for Cost Reviews

All of the plants in our company operate on a standard cost system. These standards are built anew in the fall of each year. Toward the close of the year, before we pull together the forecast for the next six months, we pick from the latest available information expected variances from the new standards and incorporate them into the planned results. Accordingly, our accountants must

COMMENTS ON MATERIALS, DIRECT LABOR, SCRAP VARIANCES

Cost Source	Variance From Standard Cost Budgeted	Actual	Comments on Causes for Actual Variances	Actual Variance Preceding Months May	June	July
Mat'l Coatings	(644)	206				
	(434)	(434)	Due to using weighted average standard rate $(252) - Greater number of sheets coated than included in weighted standard (40M) (182) - Average value of materials used higher than included in weighted std.			
	124	129	Paint Mixing Performance - Greater than standard yield - primarily on $26 white and T-315 Varnish - Note improved trend in yields	(240)	(65)	106
	(334)	511	Coating performance - Reflects full month's results from new viscosity regulator and continued special attention to film thickness. See attached detail analysis by types of coating	(151)	(263)	109
Labor	(277)	(211)				
	(160)	(160)	Due to using weighted average standard cost rate $(160) - Greater number sheets coated than included in weighted standard (40M)			
	(197)	(51)	Coating performance - See detailed analysis - Improvement needed here. Discuss possibility of (1) better scheduling of orders. (2) are incentives on setups practical? (3) higher oven temperatures & faster coating speed	(42)	(73)	(72)
Scrap	290	414	Performance - Second set of "educational" posters have been put up in department and results appear favorable.	53	172	350

EXHIBIT 1

be prepared to explain the actual variances from standard versus the budgeted variances from standard, with a full analysis accounting for the differences in these two figures.

It was these reports on variances which we did not feel were receiving sufficient attention to make them effective tools. In taking a fresh approach to this problem, we first talked with each plant manager and persuaded him of the help which was his for the asking, if he could arrange his schedule to conform with a proposed program. This program asks him to set aside one hour on each of seven consecutive days each month, beginning with the eighth working day, for staff review of the preceding month's results. Since most of our managers are in charge of multi-product and multi-operation plants, to attempt to review the entire plant performance at one time would entail at least a full day's discussion. The schedule of one hour on seven consecutive days avoids the boredom which can result from too long a period of conferring and makes it possible to limit the personnel to be in attendance at individual meetings to those interested in the problem under discussion.

Generally, the meetings, which are conducted by the plant controller, are attended by the plant manager and his assistant, the production superintendent, the industrial engineer, the chief cost accountant and the foreman of the department under review. The plant chemist is invited to the meetings in which he

can play a vital role. At times we also bring in the shift leader of the department who happens to be on duty at the time. This we have found desirable, both for our benefit and for the shift foreman's. This meeting gives him an opportunity to associate with the higher echelon of management, affords him an opportunity to "sell" himself, and, at the same time, makes him feel a part of the management team. We have found that he is able to supply details on how the department is operating and that he contributes many good ideas. In addition, we get better cooperation from him if he understands why certain decisions have been approved, particularly if he has helped make them.

How and When We Prepare Interpretation of Results

Now let us explore the first key to management motivation, interpretation of accounting data. The interpretation of data is basic in our preparation for the monthly variance meetings. Obviously this does not mean that we sit down only once a month to interpret operating data. Interpretation of data is constantly taking place and management is promptly informed of significant facts. But, at the end of the month, we pull all our findings together to establish perspective as to progress. In many cases, this preparation begins immediately after adjournment of the previous month's presentation. It is important to take a few minutes after each presentation and jot down the things which you think will make your next presentation more effective. Sometimes you will come away from variance meetings with a feeling of frustration, a feeling that you had not generated in others the same enthusiasm which you yourself had. When this happens, you and your accounting partners should sit right down and try to figure out what you will have to do in the preparation for the next meeting so that your presentation will be more effective. The presentation of monthly operating results must be made as quickly and as close to the end of the period as it is possible to do so. It is only through prompt presentation that you can keep the interest and enthusiasm high. So if you are going to make a timely presentation, then you have to start very early to interpret your facts.

We start to analyze the results of the period as soon as individual variances begin showing up. In other words, we are doing our analysis work all of the time that the regular monthly closing work is being done. We do not wait until after the closing has been completed. As we approach the fourth or fifth working day and we have an idea of the progress of the closing of individual departmental controls for materials, labor and scrap, we set up a schedule of the order in which we will hold our meetings with the various departments. All those who are to attend the presentation are notified immediately so that

they can arrange their plans accordingly. Please note that we do not operate on a fixed schedule but on a schedule which will allow us to start our presentations as early in the month as possible.

All through our work of analyzing variances from standards, we try to keep uppermost in our minds that our primary interest is departmental results. We think of the department as a separate little business all of its own, with its own individual manager, the foreman. We carry this line of reasoning right through to the preparation and summarization of the total plant variance summary. (We do not discuss, in these individual presentations, the distribution of variances to the commodities manufactured within a department. Although it is necessary to distribute variances to commodities for the final development of commodity profit and loss statements, this distribution has no value in following the costs of specific factory departments and, therefore, tends to confuse rather than assist in our presentations of departmental results.)

As the information becomes available and the results begin to take shape, we start the work sheet for each department. This is not an elaborate form but simply a sheet on which we list material, labor and scrap variances (Exhibit 1). Under each of these headings, we show the major categories of material used and the work centers in which the labor was expended or the scrap incurred. Under each one of these subheadings, we detail the items which we have found make up or contribute to the total variance. These are the facts we need to do our interpretation job. What we are doing here is simply preparing ourselves for an oral presentation of the results before the management group.

By this time, we are beginning to formulate certain opinions about the results of operations. We are determining where action is required. It is also during this time that we are deciding what information we will highlight and how we can do it in an interesting fashion, so that, when we make our presentation, it will hold the interest of the group and be thought-provoking. One of the common faults of an oral presentation is that very frequently it becomes monotonous. When interest begins to lag, discussions are prone to move on to subjects not pertaining to the matter at hand. Most production people have an aversion to accounting figures and data. They get bored very easily. This presents a challenge to figure out ways and means of holding their interest. As part of our preparation we plan how we will do this. One of the techniques is to present information in a variety of ways. This is not to say that we present data differently every month. However, after we have used one technique of presenting our data for two or three months we very frequently switch to some other method.

When we have completed the job of analyzing results, selected the specific costs on which we feel some action should be taken, and have prepared our data and ourselves in such a way that we think our presentation will be interesting, we are ready to tell others of our findings and stimulate them to take action on our recommendations.

How We Present Our Interpretations to Management

The second key to motivation is presentation. As stated, our monthly presentation of the cost data consists of a series of seven meetings held on consecutive work days. Each meeting begins at nine o'clock in the morning, giving everyone an opportunity to get his desk cleared and the controller's group to make a last minute review. Each of these meetings covers one department or one area of responsibility. As mentioned before, we do not hold these off until all of the departments have been analyzed but get under way just as soon as we can see that we will not have to interrupt the series of sessions. Usually we try to begin by the eighth or the tenth working day of the month, depending on how many problems we have run into in our closing. It is important to hold these meetings just as quickly as possible, so that we are talking about something that is still fresh in mind. When variance meetings get to the point where you are trying to tell people on the twentieth or twenty-fifth of the month about something which has happened, let us say, in the first work week of the previous month, you are too far away from the action time. And if you happen to be looking for explanations of what took place at that time you are likely to get some very incorrect and misleading information.

Each person attending is given a work sheet which shows the totals only of the major variances shown on Exhibit 1. The details or reasons for the total variance are omitted from these sheets. Space is provided under each major variance so that, as the story unfolds, individuals can write down the explanations. They are asked to do this because we have found that, if they do, the facts and figures will take hold more firmly. Thus, this becomes a real down-to-earth working session. As the controller reaches a point at which he wants particularly to emphasize how a situation has been going, whether there has been any improvement from some previous action or, possibly, where a cost situation is unfavorable, he will highlight this phase by giving each person a copy of a report which has been prepared for this particular purpose. It may be a report of some historical data or a projection of anticipated results if a present trend continues. Our purpose is to get a discussion started. From these

COST REDUCTION PROGRESS REPORT

ITEM NO. *	DESCRIPTION	ANNUAL COST REDUCTION IF COMPLETED	EST. COMPLETION DATE	CURRENT STATUS
5.	Plate maker to spend available time sorting metal in Decorating Department	$ 720	5-1	Completed 6-9. Annual savings realized $975.
7.	Personnel reduction when move man replaces retiring watchman.	3,000	7-1	Completed 7-1. Annual savings realized $2,800.
8.	Scrap Reduction Program – a. Educational posters b. Increased size of M. C. sheets. c. Repairs to #4 stocker.	6,000	5-1	Approx. 75% of savings realized. a. Second set of posters placed 6-25 b. New scrap layout sheets due from Design Section about 9-1 c. Shops promise completion 8-22
Items Added Since Original Report Issued				
9.	Automatic Viscosity Regulator for #4 and #5 coating units.	$ 8,400	6-1	Completed 7-6. Annual savings realized $9,500.
10.	Elimination of sizing coat.	52,000	*	Laboratory continuing search and tests for improved materials to eliminate size coat.
13.	Elimination of aluminum plate washing.	2,200	8-1	Completed 8-3. No detrimental effects noticed. Appears successful.
15.	Purchase 3-ply blankets instead of present 4-ply.	2,600	10-1	Tests to date with 3-ply blankets show poor results. Test blankets now running will be available for inspection 9-20.

*Items omitted have been completed and dropped.

EXHIBIT 2

discussions come ideas which are evaluated by the group. It is the ideas we are after, since ideas are the basis for action.

In this manner, we proceed from material to labor to scrap and to expense. On work sheets used for presenting expense costs, we show the current month's actual cost for each source of expense, the deviation from budgeted cost, a space for our comments and suggestions, and the period-to-date deviation from budget. All of the data shown in this work sheet are at the total departmental level, although measurement of actuals against budgets is made by work centers within each department. Later in the month, formal reports showing this detail are issued to all interested parties for their more careful scrutiny. In our presentation, we try to keep from making issues of minor deviations or dwelling on expenses which appear to be in line with the budgets. However, if a departmental figure for a particular source of expense looks close to the budget but is made up of an unfavorable variance in one work center and offset by one or more favorable variances in others, we are careful to point that out. In a month in which variances generally appear favorable and there seems to be nothing outstanding, we may impress upon those attending how substantial certain types of costs are and possibly hint that any good cost reduction idea in this area might be very worthwhile. It is surprising how many times, after making such

a statement in one of our meetings, several ideas are tossed into the mill. A great many of these are good ideas upon which action is taken at that time.

The Foremen Report on the Cost Reduction Program

After the controller's presentation has been made, the foreman is asked to make a report on the progress of the cost reduction ideas approved for his department in previous meetings. It is interesting to note how this program originates since it is such an important part of our monthly meetings. Once each year, in late fall, the manager and controller sit down and decide on a task for profit improvement for the coming year. We do this by starting out with a projected profit statement. It is a rough one, to be sure, but it gives us a starting point. We simply assume sales at the level we are currently experiencing. Costs are adjusted for anticipated changes in wage and salary payments and prices of major raw materials. We cannot be too exact at this time, but we can get a good idea of what the profit picture will look like. The profit after tax is related to the total amount of capital employed to determine the return on capital employed which, in our company, is the final measurement of the success of our businesses. A goal for return on capital is set in our company for each commodity group. After we have determined the return from this profit projection, we then study what can be done, either by reducing costs or reducing capital employed to improve the picture. Part of the task is given to production planning and purchasing staffs, and to the foremen in the way of inventory reductions. We feel this is an extremely significant part of the total task. While we in the plant can do very little about cash and receivables and have relatively little control over plant property and equipment, we do have almost full control at the plants over money tied up in inventories. Since, in most plants, this represents forty per cent of the capital employed, we study this angle very carefully.

The remaining portion of the task—to reduce costs—is then allocated to departments. This task is given to the industrial engineer. His staff works directly with foremen, the production superintendent and others. All ideas that have some merit (but for one reason or another are not practical at the time offered) are recorded by the industrial engineers. They refer to this file of ideas frequently and many of them will crop up later in a cost reduction program. The co-operation demonstrated by everyone in getting this program together is excellent. In spite of the fact that some of our tasks have been pretty steep, I have yet to see a cost reduction program which was not over subscribed.

Several days before the meeting, the foreman has met with the industrial

engineer assigned to this department and together they make up a Cost Reduction Progress Report (Exhibit 2). Each of those present gets a copy. The report shows the item number and description, the originally planned completion date, and the expected cost reduction. Alongside each item are brief comments telling whether or not the date will be met, what savings have already been accomplished, what is the status of engineering, if any is required, and so forth. This list is being added to constantly. As items are completed to everyone's satisfaction they are dropped from the report.

When the meetings are adjourned (as already indicated, we try to limit them to an hour) everyone has had a comprehensive look at the cost of operating the particular department for the month. They leave the meeting fully informed as to what has happened and what plans have been set for the immediate future. The foreman himself has been directed to take actions which everyone has agreed to. The plan is a specific one and the foreman knows that he will be expected to report on the improvement resulting therefrom in the following month's meeting.

Some Suggestions for Conduct of Cost Review Meetings

Some of the things which we try to keep in mind during our preparations for our meetings and during the meetings themselves are worthy of comment. First, try not to give management too big a dose of information at one time. By holding one meeting each day and trying to keep it within an hour, we think we get a fair share of management time for cost control without loss of interest. Inasmuch as our series consist of seven meetings, this means that the staff is starting off about one quarter of the working days in the month with cost control uppermost in minds. If we were to have departmental meetings one after another on the same day we would lose this attention very quickly.

Another point is to get people to write a circumstance down as it is presented. In that way, they will be more impressed by the information. It gives them a few moments to absorb it, keeps them alert, and helps them follow the story.

Further, try not to get into grooves, the pitfall of oral presentation. Do not be a broken record! Pick out some new phase of the cost picture each month and figure out how you can show it the most interesting way. This should not always be an unfavorable situation. Where you can see a decided improvement in a condition which had been unfavorable and had been pointed up for correction, go back and get a little history on it and present it so that your hearers can see the trend you see. However, where you have failed to get action on an unfavorable situation, keep bringing it up until some action is taken.

You do not have to be obnoxious about it. If you did not get constructive ideas the first month the situation was presented, it may be that the group was not impressed with its seriousness. Next month try it another way.

Keep your explanations simple. Always keep in mind that foremen are not accountants. They like to think in terms of pieces, people, machine speeds, and the like. They will have no confidence in you if they do not understand how you arrive at the figures. So, be persistent in your explanations but be patient. If you state a fact clearly and frequently, they will soon understand it as well as you do. You may have an educational program on your hands. Be careful how you handle it! Somewhat in this connection, a good word for good performance is a must. If credit for a good job can be pin-pointed, point it up. It is amazing how a foreman will extend himself in order to hear a little word of praise in the presence of his supervisor. If you cannot single out an individual, then direct your credit to the group as a whole. It will work every time.

Be consistently fair with the foreman. Make sure that you are not blaming him for a condition over which he has no control. For example, in trying to minimize the number of inventory standards we have, we very often build into them weighted averages to reflect certain anticipated mixtures. If you use such short cuts, be sure everyone recognizes that variances are against weighted inventory standards, not performance standards. In many of our departments we have this condition. When we explain a variance, the first thing we pull out is the amount representing the difference which results from using a weighted inventory standard rather than the specific standard. We further calculate and show separately any other costs over which the foreman had no control. Not until all such items have been withdrawn do we mention the figure which represents a measurement of the foreman's performance. We want to be sure we are not blaming him for a loss or crediting him for good performance if it is not true.

Last, don't be afraid to ask for suggestions and criticism of your presentation. Find out which features of your presentation appeal to the group and which ones they do not find helpful, and make corrections accordingly. There is no secret formula for the successful communication of facts to management. Nor can it be said that any list of techniques for motivating plant management at one plant will be effective in another plant. Common sense, good judgment, a little elementary psychology, a thorough knowledge of plant operations and personnel and an aggressive approach are required. Each one of these plays a part in getting across to the management group the story you have to tell in a way that will hold its interest, encourage ideas, and stimulate action.

Organizational Dimensions of Effective Budgeting—An Experience

by

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When, as in the case at hand, a relatively new plant initiates budgeting for control of costs, it may find that neither plant management nor general superintendence nor worker supervision are fully clear as to the scope and nature of the undertaking, the type of training required, the time it will take, and the new viewpoints needed. It is indicated in this article, however, that the story is destined for a happy ending in cost results and organizational relationships, if, among the discoveries, the foremost is the need for budget participation "in depth" throughout the plant.

THIS ARTICLE WILL BE an attempt to tell briefly how the initiation of budgeting for a division of a machinery manufacturing company was turned into a program of organization and education. The division is a relatively new one. There has been a process of growth from a small beginning to a present work force of approximately 2,700 people. Inasmuch as the facilities and manufacturing tasks of the division are different from the other manufacturing divisions of the company, little could be borrowed from them in developing the management plan and control processes needed. At the time an organized approach to budgeting began (about a year previous to the writing of this article), the division was still involved with setting up adequate manufacturing procedures and increasing the skill of the relatively inexperienced management work force.

The task of developing a sound budgeting program was assigned to the accounting department. It would have been most helpful to have had an organized working guide for the progress of the budget program. However, even if something like this were available, the division still would have been plagued, as it was, with the common obstacle faced daily by business management. How do you put principles into practice? This company's experience suggests that each organization must find its own way to proceed, since no two situations will be exactly alike.

First Steps in a Cooperative Endeavor

Very early the budget accountant began going into the factory to confer with line management as to the accuracy and specific nature of the cost figures which he was collecting. This practice made certain that the line supervisors were involved from the beginning in the process of establishing a cost base upon which future planning could be made. It soon became clear that the accounting department was not providing cost information which was sufficiently accurate or in a form which non-technically trained persons could understand and use. It also developed that the management of the several line departments were somewhat confused as to the groups of personnel and the cost accounts for which they each were or should be directly responsible.

Several changes resulted from these discoveries. The first involved putting the accounting department's procedures and accounts in order. Cost accounts were more clearly defined. Duplication in the reporting of costs was eliminated and simplified forms for reporting costs to all concerned were developed.

Moreover, through study and conferences between accounting and line personnel, responsibility for activities reflected in the accounts was more clearly and definitely fixed.

Still further, it was concluded that an entirely different procedure for collecting and reporting costs must be set up. The objective here was to establish an equitable method for apportioning overhead expenses to the many different products which the factory produced. More than anything else, the complex situation of manufacturing both government and commercial products forced this decision. However, the decision was not made by the accounting department. Instead, the controller brought the problem to the board of managers' meeting (a weekly meeting of the plant manager's department head staff). This broke tradition by involving line officials in the question. The problem was discussed several times before the decision was made. When the accounting department had the new system of cost reporting ready to install, the controller brought the plan before the board of managers for a complete discussion and review.

While this decision making was occurring, budget planning had begun throughout the plant. The accounting department provided each operating department with a special budget worksheet upon which was inserted the actual expenditures of the department for the previous period. The department was then asked to complete a second column which was to be its budget for the next accounting period. Again, it may be said that the budget accountant broke tradition, in seeing to it that these forms were usefully handled. Rather than

merely issuing the forms and setting a due date for their return, he went to each department manager and spent as much time as was necessary in helping him understand the nature of each budget item and how to plan ahead for it. These discussions were not one-sided in their conduct or benefits. Although the budget accountant had had factory experience, he had never worked in this factory or on the particular products produced. The department heads, building superintendents and general foremen provided him with vital details of operations and cost management problems, which enabled him to better understand the needs of the plant and to sharpen considerably his account definitions.

Nevertheless, after several months on the allowances worked out, it became discouragingly apparent that merely the making of a budget was not going to achieve its objectives. Actual costs continued to be sharply over or under the budget estimates—and always over in total. To meet the situation, top management resorted to traditional practices and, in line with it, the accounting department issued memorandums viewing with alarm the consequences which would follow if the budgets were not met. The plant manager harangued his department heads and issued tight restrictions on the hiring of new personnel. Building superintendents and general foremen spent many hours over departmental figures and admonishing the front line supervisors. However, this did not seem to be the right medicine. At the end of the next budget period, expenses, especially overhead, were as badly out of line as before.

Straightening Out Organizational Responsibilities

Upon analysis of these experiences, two principles of budget management emerged. The first principle is that intelligent budgeting cannot be accomplished through threats of punishment, moral admonitions, or pure technical advice. Nor can it be accomplished simply on the honest desire of people to carry out their responsibilities. In other words, there is a "how" of budgeting which management must learn. The second principle is that budget planning is dependent for success upon the attitudes and skills of those who spend the money. It came as a great surprise to some in middle management to discover that they spent very little of the company's money. Who did the spending? By the nature of their functions, the front-line supervisors—the foremen and office supervisors—made decisions hourly which totaled up to the operating cost figures at the end of the day or accounting period.

Hence, along with budgeting efforts and not at first explicitly related to them, a program was begun in supervisory training. The procedure was to train the general foremen as instructors and then ask them to conduct discussion sessions

with their own foremen. Previously, all members of management who were to do this had received training in the art of discussion, leadership, and conference participation. These skills were put to good use in the training sessions. The first subject area treated was identification of the duties of the front-line supervisor. As the discussions developed, it astonished some superintendents and general foremen to learn how uncertain many foremen were and how great the difference of opinion many held as to just what their responsibilities as foremen should be. Also, there came the realization that it was not enough just to list the foremen's duties, i.e., to say that they include being responsible for safety, keeping down overhead costs, hiring new employees, etc. How to accomplish these duties must be studied also. A long series of weekly "how to" sessions were started as a result of this insight.

These training discussions made it obvious that, as long as the formen had so much to be learned as to how to do their overall job, budgeting was in for a hard time. During the discussions, the front-line supervisors put up to their supervisors, the general foremen and department heads, the following proposition, in effect, "If you want us to assume responsibility for keeping within the budget, you must let us know what is in the budget and further we must be consulted in planning the budget." This was clear evidence to all that, up to this time, the departmental budgeting and planning had gone no deeper than the building superintendent and general foreman level. The general foremen made immediate plans to carry budget planning down to the operating foremen at the beginning of the next budget period.

We Taught Budgeting to All Management Personnel

The accounting department's time table for setting up the new cost accounting system coincided with this change of attitudes and procedures in the factory. Under the new methods, cost centers were identified at the operating or foremen level. Thus each operating department was broken down into cost units or centers according to the sections or areas supervised by each foreman. It was then possible to break down the departmental operating costs by foreman-focused cost centers. Out of this came the opportunity to provide each foreman, monthly, a report of his actual expenditures and thus equip him for the first time with the necessary data to plan a budget in terms of his known needs. The departmental budgets became the summary of these cost center budgets.

The "how to" training sessions at the foreman level, i.e., down to the last man exercising part of the authority of management, offered another opportunity which the budget supervisor immediately put to use. One of the first

discussions was on budgeting. All management personnel, from the department heads down through every foreman, were required to attend discussion sessions on the necessity of and the procedures for making and keeping a budget. The budget supervisor conducted these discussions. The groups were kept small (about fifteen to a group) and discussion accompanied by lots of questions formed the operating procedure. Each supervisor was provided a cost accounting manual in which was carefully defined the various cost classifications. The groups took up practice cases requiring them to use the manual, so that they learned how to report their costs more accurately. They were given practice in calculating budget items. Throughout these sessions, the importance of sound cost management—especially overhead or burden cost management—was stressed in terms of its importance to each of them as supervisors.

We Have Found Out . . .

As this is written, a final evaluation of the year of effort to establish an effective cost control system cannot be made. Many of the initial activities are still under development. Policy making still fails, sometimes, to consider adequately the budget factors involved. Some of the foremen did help prepare the budgets they are now using and monthly each foreman is receiving a report of his actual expenditures. Just how far the foremen will be allowed to go in planning their own budgets and just how much responsibility they will have to carry on the actual control of costs is not yet clear. However, some conclusions concerning progress can be made. It is believed that this progress has been sufficient to entirely justify the expenditures in time and personnel which the budgeting activities have required. Progress has been of two types, accomplishments of a more or less technical nature and insights of an organizational or management nature.

In the first category, department managers and line foremen have been made aware that there is a method of measuring their operations in a way which now appears both logical and beneficial to them. This has resulted in their becoming watchdogs of departmental expenditures rather than leaving this responsibility to a handful of persons in the accounting department as had previously been the case. Further, departmental responsibilities as to personnel and to the acquisition of materials, supplies and tools have been fixed. Additionally, the tendency to over-buy certain supplies, forms and fixtures in order to take advantage of lower prices has been curbed to a large degree. Also, there is better management of workers. Front-line supervisors now realize that it is more important to keep a production worker producing salable goods than it is to

divert him from this type of labor for such things as washing windows or sweeping floors. Prior to the instigation of budgets, it was a common belief among line management that all you had to do to get a fair return from a man's labor cost was just to keep him busy, regardless of the tasks to which he was assigned.

As to insights concerning the management process, it has become clear to all of us that effective budgeting depends upon strong leadership. A simple, well-coordinated management organization must be present. If departmental functions and responsibilities are not clearly understood and accepted, if communication among the several departments is weak, the budget program does not have a chance to succeed. The process of setting up and operating a budget program results in strengthening the management function but cannot be accomplished without an underlying sound philosophy of management plus valid concepts of the requirements of procedure. It also came clear that building and operating a successful budget program is a process, not something which can be done all at once. Using enough time to do the initial job adequately and recognizing that the job is never finished are important realizations. Experience must accumulate and be evaluated. Conditions and needs change. Budgeting is a dynamic rather than a static activity. Finally, we came to the conviction that budgeting is the responsibility of all of management. Thus, all who by their activities directly affect the cost picture must be involved in studying the problems, planning the remedies and executing the plans. A basic principle is to keep decision-making directly related to line activities and needs.

Sales Incentives Aligned to Company Objectives

by A. G. PATARD

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At the heart of this paper, which reports successive experimental, progressive, and currently improved salesmen's incentive bonus applications of the background company, is a four-point philosophy related to such plans. These points require, if they are to be put into practice, that the company take responsibility for analysis of sales conditions in and goals for its territories, culminating in quotas which are reliable standards of sales performance.

ONE OF THE MORE PERPLEXING problems confronting sales management today is that of an incentive bonus plan which will accomplish its purpose reasonably well. I would venture to say that millions of dollars are spent annually by industry in administering salesmen's bonus plans, to say nothing of the countless hours expended annually by executive and administrative personnel in constantly devising, investigating, revising, discussing and reviewing these plans. The obvious preference of so many companies for a combination of salary and commission or bonus, i.e., an incentive compensation plan, is an attempt to gain the advantages of both straight salary and commission plans and, at the same time, to offset their individual weaknesses. The purpose is to avoid inadequate, or excessive compensation and gain a favorable balance of security and incentive for the salesman. A great deal of emphasis is placed upon the adequacy of salesmen's compensation in incentive bonuses systems and it is of major importance. No compensation plan can exist for long unless it meets the test of adequacy. The requirements of adequate income form a moot question and opinion varies. Experience, perhaps, within the individual concern will prove the average level of compensation which will attract and hold salesmen of the required caliber without distorting the company's general wage pattern.

Three Superseded Plans

In the Lighting Division of Sylvania Electric Products, Inc., we have used a number of plans for compensating salesmen in the past. We manufacture products for a relatively stable market, which include incandescent and fluorescent lamp bulbs and fluorescent lighting fixtures. Our history of salesmen's compensation is probably similar to that of many other concerns during a period of growth. For a time a straight salary plan was used. In some areas a straight

commission plan was employed. Both fell by the wayside as the company grew and the need became apparent for a method of compensating salesmen in a manner which would give them reasonable security and yet motivate them to give specific attention to the company's objectives.

In 1944, a so-called "straight" bonus plan in addition to salary was introduced and, in 1945, the bonus plan was revised and designated as flexible. Under the straight bonus plan, a flat sum was paid for attaining quota on all products for the month, plus an increment for exceeding quota. In the flexible plan, the incentives for each month were determined on the basis of whatever product or problem needed to be pushed at that time. Neither plan endured very long because it quickly became obvious that they were basically in the nature of contests. They provided only a temporary spur and did not contribute to the establishment of coordinated analysis and planning on the part of the salesmen, which is the basic intent of a bonus incentive plan.

An important forward stride in salesmen's incentive bonus compensation for Sylvania was made in 1946, which placed some emphasis upon expense control and full-line selling by basing the bonus on the salesman's salary and traveling expenses. In this plan, basically, budgeted salary and travel expenses for each salesman were capitalized at two per cent, accomplished by simply multiplying by fifty to establish a quota. A bonus of one percent was paid on sales in excess of quota. Particular characteristics of territories, such as high competition, low development, extensive area and expensive travel, were adjusted by deducting an amount from the quota. Conversely, if the territory was well-developed or concentrated in a metropolitan area with low traveling expense, an amount was added to the quota. A second set of quotas was then developed for each of the three major products. These became sales volume objectives and, in total, were higher than the capitalized expense quota. To induce full-product-line selling, a penalty of one percent of the total bonus was deducted for each one percent by which sales of any of the three major products fell below the sales volume objective of the territory.

For about a year thereafter, our salesmen were highly conscious of their traveling expenses because their quota, arrived at by capitalizing their expenses, varied with it. For each dollar that they exceeded their travel allowance, they lost fifty cents in bonus but, for each dollar that they operated below their travel allowance, they gained fifty cents in bonus. (We occasionally heard that some of our salesmen were becoming highly adept in the art of out-fumbling their customers in reaching for dinner and entertainment checks. After a while, whenever this feature of the plan was emphasized to a group of salesmen by telling them that for each dollar saved in traveling and entertainment expense the com-

pany would give them half of it, some salesmen would usually observe that he would rather have all of it. Despite these facetious observations, this feature of the plan did furnish the salesmen with a yardstick for measuring and personally budgeting their expenditures with relation to the volume of business involved with each of their customers.)

The plan served for seven years. It was launched with some formality, including a description before a public gathering. Considerable attention has been focused upon it in a number of publications, which implicitly cited it as one of the more forward-looking of incentive bonus plans. Nevertheless, it was never received with any amount of enthusiasm by our district sales managers and salesmen. Rather, it was accepted with a feeling of cautious reserve which we were unable to dissipate and, as time went on, this grew into opposition. During the declining years of the plan, whenever company officers ventured out into the field, they were buttonholed by the district sales managers and salesmen who pointed out features considered unfair. At sales conventions, the bonus appeared high on the agenda for closed sessions with district sales managers.

The plan was discontinued on December 31, 1953. However, its period of existence had given us a liberal education in salesmen's incentive bonus compensation, because of the points it raised in all circles in the company. Through the very circumstances of having many people of both high and low positions vitally interested in the problem, its solution was speeded. A review of the plan not only revealed to us where it failed but placed clearly before us the objectives important to an incentive bonus plan and gave an awareness of the many related factors in a distribution cost program which must be correctly handled in conjunction with the plan, in order to make it successful.

The Fatal Defect

The greatest difficulty with the old plan was the manner in which the salesman's individual sales bogey or break-even point was arrived at. The arbitrary adjustment factor added or deducted in an attempt to equalize for differing conditions in each salesman's territory, was the factor which proved to be the root of the salesmen's suspicion of plan. It varied by salesmen as well as from year to year. It differed between salesmen having similar sales volumes. Although it was an honest attempt to equalize for varying conditions, it neglected to place before the salesman the condition of his territory as compared to other territories, nor the specific role that his territory was designed to play in the unfolding of the company's immediate and long-term sales objective. Consequently, the basic need and incentive for analysis and planning at the salesman's

level was lost because he could not envision the company's picture and his specific role as a contributing factor.

Principles Involved in Constructing a Salesmen's Bonus Plan

In approaching and formulating a salesman's incentive bonus plan, four basic elements may embrace its entire concept:

1. It must be easy to understand.
2. It must be, in effect, individual to each salesman.
3. It must furnish equal opportunity for every salesman.
4. It must furnish continual incentive to the salesmen to accomplish the company's sales objectives.

Probably any sales manager or salesman, if asked to specify his requirements in a salesmen's incentive bonus plan, will include the first objective. This requirement is truly basic. In order for a bonus plan to fulfill its mission, it must be simple enough for the salesman to measure his planning and efforts immediately, without going through a maze of mathematical computations. The main objective of the plan needs to be clearly defined in a single specification but, and this is of extreme importance, that objective must be supported by complete analysis and information concerning the condition of his territory, its relative development compared to other territories, the company's objective for that territory in relation to the overall objective of the company, and the company's plan for the development of that territory. In this manner, the salesman may be motivated to utilize his abilities of planning and analysis in the attainment of the objective.

As to the second point, although team plans may have some merit in isolated cases, basically they reflect the inability or unwillingness of management to thoroughly study and determine the condition, markets and objectives of each salesman's territory. It is not uncommon for many companies to shift this burden to district sales managers under a misguided or frustrated idea that no one can be expected to know the territory except the man who travels in it. However, a district sales manager is primarily a salesman with an ability to manage men and to devise and carry out merchandising plans. He should not be required, and generally is not equipped by training—nor does he have the time—to carry out the functions of market research and distribution cost analysis. Companies which will properly study and analyze each of their salesmen's territories can come up with an individual incentive bonus compensation plan which is practical and desirable.

Direct comment on the third requisite of a salesmen's bonus plan requires, first, a look at quota-setting. There probably is not a salesman alive who does

not recognize the term "sales quota" and there undoubtedly are relatively few companies of any consequence which do not establish sales quotas for their salesmen. Sales quotas are probably generally established upon about as unscientific a basis as is used in the selection of a woman's hat. Methods vary anywhere from using the sales volume of some year as a base year or the average of the sales volumes of the three immediate previous years, to asking for and accepting the sales estimates of the salesmen in the field. Yet sales quotas should represent a standard of sales performance for each territory. (Can you imagine a factory standard being established by asking the workmen how much they think they can do? Or by averaging a particular workman's output over some previous period? Or by having a plant manager or foreman guess what would be about right?)

The subject of sales quotas is a detailed study in itself and, although basic to this article and salesmen's incentive bonuses, is outside the scope of discussion. Even to begin to intelligently establish sales quotas as standards of sales performance requires: (1) specific knowledge of the potential market in each territory, county, city and town, (2) an intimate knowledge of the channels of distribution, (3) the characteristics of each market, (4) competition in each territory, and (5) buying habits of the end user. Equipped with this information, standards of sales performance or sales quotas may be intelligently established for each territory and, from them, the advertising and merchandising departments can more intelligently plan their programs to aid and abet the salesmen in attaining the immediate and long-term objectives for their territories at costs which are competitive or better.

If standards of sales performance or sales quotas for each territory are properly established, it automatically follows that each salesman will have a relatively equal opportunity in any incentive bonus compensation plan based upon the attainment of such standards. The problems of so-called windfalls and split-sales credit will always remain to plague a salesman's bonus incentive plan, but these problems are the excepton rather than the rule in most companies and, with a proper analysis of sales territories, such isolated cases can usually be intelligently resolved.

As to the final requirement continual incentive to achieve the company's objectives can motivate salesmen if the objectives are realistically determined through sound and adequate market analysis, so that clearly-planned merchandising and advertising programs will efficiently aid and abet each salesman in the attainment of the well-defined objectives for his territory. And the bonus plan can become an intelligent reward instead of an elusive "carrot dangled before the rabbit's nose."

The Current Plan

Since January 1, 1954, the Lighting Division of Sylvania has based its salesmen's incentive bonus plan upon the principles outlined in this article. Sales quotas are established for each salesman by product with all of the available market analysis knowledge of our distribution cost and market research departments in personal conference with our merchandising staff and district sales managers. The past history and current condition of each territory in relation to market potentials are studied and immediate and long-term goals are defined for each salesman.

We pay every salesman the same amount of bonus for attaining his sales quota, regardless of the varying calibre of the salesmen in the various territories. This is because the sales quota is a standard of sales performance for the territory and the salesman's calibre or ability is expected to be reflected in attaining (or exceeding) it. The sales quota or standard of sales performance may and probably will vary from year to year, based upon the condition of the territory, anticipated economic conditions, and the long-term goal for the territory. The salesmen are made aware of these factors and, if they will, can almost predict what their sales quotas will be in advance of determination by the company. However, the quota is never changed during the year.

We start to pay bonus to every salesman at seventy-five percent of quota. The bonus is a specified dollar amount for each one percent (of quota) by which he exceeds seventy-five percent of quota. At ninety percent of quota, the specified dollar amount is increased by fifty percent for each one percent (of quota) that the salesman exceeds ninety percent of quota. This, we believe, offers an added inducement to the salesmen to get into a higher money-making bracket and the company is willing to pay more in view of its long-range objective. It feels that salesmen who are attaining this objective in their territories are entitled to a higher rate of payment than those who are not. For the same reason, the specified dollar amount for each one percent of quota is doubled for attainment in excess of quota for most territories.

However, like most companies, we have some territories not as well developed as others and, consequently, because we anticipate a slower rate of development or believe that such territories cannot ever be expected to attain the degree of development of others, we have to establish comparatively low sales quotas or standards of sales performance. Yet we are afraid that we could be wrong in some instances in establishing lower quotas in those territories. To guard ourselves against the possibility of serious error, we pay off on a percentage of sales in excess of quota instead of on a percentage of quota. This is a defensive

measure and contrary to our expressed philosophy of continual incentive through proper planning. It is an admission, whether we like it or not, that our market research and distribution cost analyses have not yet progressed enough to support our standards of sales performance upon a sufficiently strong structure.

Salesmen's Incentives Must Be Placed in Perspective

We at Sylvania in common with most other companies, have a long way to go in the broad area of market research analysis and distribution cost planning of which salesmen's incentive bonus plans are but a part. We have recognized the problem and believe we are proceeding as fast as we can in the right direction. However, when the emphasis which has been devoted to factory cost accounting in most companies, as well as to quality control and the establishing of standards, is compared with the emphasis given to distribution cost accounting and market research, the latter has had, until recent years, the stature of a poor relative and the results have been in about the same proportion.

With the increasing awareness of forward-looking companies to the opportunity and necessity of maximizing profits by employing market research and distribution cost analysis as a means to directing the component elements of marketing efforts so that they are applied in closer proportion to the sales potentialities of different segments of the business, the situation should be better and the frustrations and dissatisfactions experienced over incentive bonus plans should be less. Salesmen's incentive bonus plans should be and can be relatively simple. They have been asked to carry too much weight in the distribution and cost picture. Too little emphasis has been placed upon standards of sales performance. In effect, we have been hopefully trying to get the tail to wag the dog instead of properly training the dog to wag the tail. Along with the building of a solid structure of marketing knowledge and territorial analysis, there is every expectation that the problems attached to salesmen's incentive bonus plans will be resolved and the bonus plans will be enabled to fulfill their mission of additional compensation to salesmen for achieving sound standards of sales performance at costs which are competitive or better.

Accounting For Promotion When Samples Are Salable

by GEORGE C. LYON

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The methods by which a mail order company specializing in what is indicated to be virtually a printed product, initially defers and then writes off its advertising, promotional mailing, and substantial sample costs are described in this paper. The material given covers the financial accounting for these costs for the purpose of matching income and expense, but the development of control along the lines of the accounts and entries used is also set forth as an objective.

THE BASIC TOOL OF CONTROL is the operating budget from which budgetary standards are derived, in addition to numerous other tools for controlling, analyzing and reporting cost performance. Because the company serving as background for this study is a direct selling mail order house, we are very much concerned with the measurement and control of selling expense and these costs will receive the center of attention in this article. We find that the company uses a mailing list containing many thousands of names of people who have actually purchased merchandise as independent agents for resale by personal solicitation, usually on a door to door basis. The mailing list is constantly changing by the elimination of dormant names and by the addition of new names obtained through national advertising. It is constantly being added to through sales promotional mailings, to provide sale of more merchandise and, consequently, more purchases from the company. This constant activity in producing sales is a costly procedure and is placed for accounting and control under the general heading of sales promotion expense.

In order to properly present the lines of merchandise offered, which have two yearly style changes of a very complete nature, it is necessary to send out to the agents a representative set of samples of the most important items in the line, as well as catalogues, broadsides and other descriptive pieces. It has been found impractical to expect any significant response to the promotion from descriptive pieces or illustrations in a catalogue alone, so the company sends out standard merchandise as samples. These are representative of the new line and, in fact, can be and often are sold and distributed exactly as is the regularly ordered merchandise. The three categories of sales promotion expense are then:

1. Advertising
2. Sales promotional mailings
3. Sampling.

The business is highly seasonal, with two peaks in sales volume, February-March and October-November. It is, therefore, apparent that special treatment of selling expense is required and it is here where we must leave the conventional methods and introduce special tools for the special purpose. The special purpose is to properly reflect the selling expense in interim periods and to apply or absorb these special selling costs to the sales volume actually attained in each accounting period so that income is not distorted either favorably or unfavorably by the incidence of the outlay for these purposes. The special tools we use in this case are a group of special entries to special accounts which are, in accounting terminology, in the nature of deferred charges or prepaid expense but which, because of the very large amounts involved, cannot and should not be accorded the usual treatment given prepaid insurance and other conventional prepaid expense and deferred charge accounts.

Advertising

Let us start our description of these special methods with the first category. Advertising in national magazines, local newspapers, nationally circulated newspaper Sunday supplements, radio, television and by means of purchased mailing lists is carried on continuously, but reaches two extreme peaks twice each year in the periods preceding the sales peaks, i.e, in January and in July and August. Large appropriations are made like those now to be cited. Although all figures used in this discussion are fictitious, the proportions are realistic. In January the appropriation might be $200,000 and in July and August another $200,000. The remainder of the year would total another $100,000, for a total advertising appropriation of $500,000. By recognized statistical methods, proved by many years of experience, certain sales forecasts can be derived from the total advertising appropriations. Let us assume, therefore, that we have determined that the $500,000 appropriation for advertising will produce $5,000,000 in sales.

Advertising expenditures are charged to a deferred expense account and the expense rate is budgeted at ten per cent to each sales dollar. As sales are made, the deferred account is relieved of the amount equal to ten percent of the sales and current expense account is charged with the same amount. Assuming that, at the end of the fiscal year, sales were exactly $5,000,000 and total advertising cost was $500,000, the deferred account would be cleared and the final result would be a charge of $500,000 to sales promotion expense-advertising.

We have presented nothing very startling in this application and we are sure that it is a fairly common method. However, we must consider the actual

application of the method under varying conditions, some of which might be a lower or higher sales volume than budgeted or an increase or decrease in advertising costs for numerous reasons, including policy changes during the year. It is in these cases that the control accounting technique departs from the conventional and brings into play the exercise of judgement, statistical methods and forecasting and budgetary applications.

At the close of each accounting period, the budgeted sales are compared to the actual sales and the budgeted charges to the deferred account are compared to the actual charges. Unless a major revision in the sales forecast or budget has been made, the method is fairly simple. Actual sales for the period and year to date are added to budgeted sales for the balance of the fiscal year and actual charges to the deferred account are added to budgeted charges for the remainder of the fiscal year. A current rate is derived, which is used for charging expense and relieving the deferred account for the period and year to date only. To illustrate:

	Budget	Actual
Sales for period ending January 30	$ 200,000	$ 150,000
Charges for period ending January 30	200,000	230,000
Sales for remainder of year	4,800,000	4,800,000
Charges for remainder of year	280,000	280,000
Total sales	5,000,000	4,950,000
Total charges	500,000	510,000
Budgeted rate:	10%	
Current rate applied:		10.3%

The deferred account would reflect:

	Budget	Actual
Charges for the period ending January 30	$220,000	$230,000
Credits " "	20,000	15,450
Balance " "	200,000	215,550

And the expense account would reflect:

Charges for the period ending January 30	$ 20,000	$ 15,450
Standard expense @ 10%		15,000
Variance		$ 450

In the event of a continuing severe decline in sales, a major budget revision and sales forecast would be made, in which case the write-off would be accelerated on the same basis. In the case of a continuing increase in sales without a proportionate increase in advertising costs, the write-off would reflect a lower rate for expense.

Sales Promotion Mailings

Typical charges to this account would be printing, postage for mailings, copy and layout, art and design, etc. All charges are accumulated in a deferred account (exactly as for advertising) and which is generally supported by an inventory, although the material thus produced is not otherwise treated as inventory, (principally because of the short cycle between its production and distribution and partly because it has no intrinsic value except for a relatively short period). The treatment of this type of expense is identical with the method described for advertising and it would serve no purpose to repeat the description and illustrations. It might be commented that the incidence of the actual charges is not so irregular as in advertising.

Sample Costs

It is in the third category, i.e., samples, that we find the most unusual treatment and in which the departure from conventional accounting methods is most marked. In order to completely understand the situations, it would seem necessary to having a thorough understanding also of the meaning of the term sample and the purpose and method of distributing samples. It has already been pointed out that the samples in question are, in fact, regular salable merchandise and are not marked or identified in any way as samples nor do the sample sets have any special characteristics not found in the regular line.

Samples are sent out in two large classifications. The first includes those sent to established agents or dealers who have indicated their willingness to accept and pay for them or, at least, accept them on approval for examination, with the privilege of returning them at our expense. The second includes those sent to people who answer the advertising and who have indicated on a cut-out they will accept the samples on approval and return them at the company's expense or pay for them. There are several sub-classifications in the first group, which classify the agent or dealer on his historical sales volume from sales records. From this the size and variety of the sample sets sent to him is determined. Obviously, this procedure is not without risk—a considerable risk, indeed. It is, however, to use a well-worn phrase, a calculated risk. Not all of the people who receive samples pay for them. Quite a large number return them at the company's expense, but the people who keep the samples and pay for them are the real objective of the whole program.

Some, a very small proportion, will keep the samples and pay for them at what is actually a wholesale price, for their own use. The great majority will use the samples for display, take orders and sell merchandise, to their profit and

to the company's. It has been found after many years of experience and from an analysis of a very complete and detailed statistical sales file that certain fairly rigid ratios can be used to determine in advance how many of a given segment or classification of individual agents will pay, will return, or will not pay. Ratios used for determining the behavior of prospects are not quite as reliable but do not vary too greatly within a comparatively narrow range. Furthermore, it has been reliably established from statistical records that unpaid sample accounts can eventually be collected down to a very small percentage for which the cost of collection exceeds the return. Collection methods, based on long experience, are fairly well standardized and the expense of collection is included in the general category of sales promotion expense and handled in the manner which has been described.

One more important fact should be emphasized. The volume of samples sent out in the case we are discussing is very large and can in no way be compared to samples supplied in most businesses. We will use fictitious figures but it can be assumed for the purpose of this discussion that twenty-five percent of the total production is used for sampling. It is because the sampling procedure represents such a large proportion of the total production as well as the total distribution cost, that the special treatment we have applied seems, after several years of experience, to be the most practical, the most reliable, and the soundest method for controlling this type of expense.

Sample volume contributes in very large proportion to manufacturing activity. It contributes substantially to manufacturing burden, as the type of merchandise is basically a printed product and high volume runs result in low unit costs. Because samples are manufactured and sent out far in advance of the normal seasonal sales periods, the production of samples contributes substantially to maintaining level operating activity in both manufacturing and shipping departments. To all practical purposes, shipment of a sample is a sale and is so treated in this case. The cost of manufacturing the sample is at the same standard cost as the regular line. The cost of packing, shipping, handling through the mail order and statistical recording departments is almost identical with the cost of handling a regular order and because the sample volume is such a large part of total volume, we apply and absorb general and administrative expense to the "sale" of samples.

Some Figures Illustrating Accounting for Samples

Before discussing the details of the method of handling the loss resulting from unpaid and returned samples, let us look at a typical (although entirely fictitious) budget as an example:

Billed value of samples sent out at standard price	$1,250,000
Budgeted payments at standard price	875,000
Budgeted returns at standard price	125,000
Budgeted loss (unpaid samples) at standard price	250,000
Budgeted sales from samples	3,750,000

Please note that we are not for the moment concerned with cost of goods or applied expense, which, however, is carried on a standard cost basis. Using the budget set up above, we will send out $400,000 worth of samples at their standard billed price in, let us say, January. Let us assume that during the same period, regular sales were only $100,000 (as the samples have not yet started to "sell"). All cost and expense for the period has been related to the production (or inventory value) and handling, shipment, and recording of samples. The income statement for the month would therefore show sales as follows:

Regular sales	$100,000
Sample sales	400,000
Total sales	$500,000

All cost (inventory cost) and expense would be applied, as it most certainly should be applied, to the gross sales, i.e., billed value of the total sales of $500,000. It is true, of course, that we will never collect the whole of the $400,000 of billed samples shown above. It is equally true that we will never recover the cost and expense of sending out all of these samples, except in the case of returns and then only a part of the total cost and expense will be recovered in the form of inventory, less spoilage. Nevertheless, it should be noted at this point that in any line of merchandising, on open account credit, it is seldom that 100 per cent of the billings will be collected. The difference in this case is in the degree or the amount that will not be collected but not in principle.

From the budget above, we see that we will lose $250,000 in sales value for uncollectible samples. This is the gross sample loss. We also will lose $125,000 in sales value for the returned samples. There must be added to this the cost of the return shipment and the cost of inspection and repacking the returned merchandise to put it back into current inventory. Inventory is charged with the net standard cost of actual quantities returned to inventory. All of these costs have been standardized and, for the purposes of this study, we will say that the net cost of returns is $75,000. The total sample loss expense is thus standardized from the budget at $325,000. The total sales, including sample sales, are then used as the budgetary control for determining a standard rate

for sample loss expense, i.e. $325,000 divided by $5,000,000 or 6.5 per cent.

We will not attempt to detail the journal entries or transactions completely but will illustrate the procedure followed:

Period: January			
	Regular sales	$100,000	(cash sales)
	Sample sales	400,000	(credit sales)
	Total sales	$500,000	
Cr. Sample sales	$400,000		
Dr. Accounts receivable samples		$400,000	
Cr. Reserve for unpaid samples	80,000		
Dr. Deferred sample expense		80,000	

A brief explanation of the foregoing is needed. We determine from standard applications the reserve to be set up against the sample account receivable for unpaid samples and show the accounts receivable at net of the reserve on the balance sheet. The reserve is then relieved by a charge to the deferred sample expense account. The deferred sample expense account is then relieved by the application of the expense rate on total sales (in the case above $32,500 —6.5% of $500,000) and the charge to the selling expense control made for the period. The returns allowance is calculated in the reserve which has a variable standard based on the specific groups or classes of samples billed and which changes with each period. Payments for samples and the sales value of the returns are credited to the accounts receivable. Returns are naturally a deduction from gross sales at the sales value.

As in the case of advertising and sales promotion, there are several causes for a variance in the application of the sample expense rate, but the total variance moves within a fairly close range. Some of the variances are, for example, higher or lower than standard rate of payment or returns, and higher or lower sales in both samples and regular sales than budget, and several combinations of these varying conditions. If sales are exactly on budget and payments and returns are exactly on standard, the net result at the end of the fiscal year is identically the same as if the samples were not treated as sales but by some other and much more complicated and less practicable method. The writer invites any suggestions as to a more practicable method, bearing in mind the facts outlined above regarding the nature of the sample program and always remembering that samples are never given away, but always sold. Under our method during the interim, the period results reflect as closely as possible, the progress of the whole sales promotion program, its costs and expense, and the wholly realistic "facts of life" in the business at the time and point of measurement.

A Profitable Tool for Measured Promotion

At the end of the fiscal year, assuming that no expense in the three categories of expense discussed in this article has been incurred for the next selling season or fiscal year, we carry no deferred charges on the balance sheet. The sample accounts receivable figure thus reflects nothing but a statistically proved and sound estimate of the net amount collectible in the next period, which generally is a very conservative estimate.

In conclusion, it is clear to us that we have at hand a relatively simple, highly reliable and most effective tool for revising budgetary controls in the promotional cost area, applying sales promotion expense to projections, and keeping a close check on the behavior and tangible yield from this very substantial investment in the future in terms of sales to be realized. After a number of years of operation, we are getting increasingly reliable statistical and accounting ratios and standards, all based on very comprehensive, dynamic and consistent application of this special type of expense. The company feels that the samples, when they go out in the mail twice a year, are salesmen on the road working for them. It is realized, of course, that there is always the inherent risk in the procedure but, in this particular segment of the mail order business, there apparently is no other successful method of inducing sales and supporting a profitable and growing enterprise.

We Studied and Applied Statistics for Control

by EARLE N. MARTIN, SR.

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Two approaches are effectively employed in this paper and both work toward placing statistical methods as a tool in the hands of any industrial accountant who will "unclench" his preconceptions in order to receive it. The first approach, occupying the forepart of the article, culminates in identification of four levels of understanding principal uses of statistics, only one of which requires the professional statistician. The second approach, which comprises the remainder of the paper, is a thoroughly readable description of how statistical methods were introduced into the author's company for cost and other purposes and how, for illustration, they were applied to controlling weight tolerance in a packaging operation.

BUDGETS, FORECASTS, STANDARDS and accounting have often been referred to as the tools of management. The industrial accountant, and the entire management group of which he is a part, have recently been introduced to a new and powerful tool which has been tailored to meet their every need in the solution of the problems of industry. This new and powerful tool is referred to as "applied statistical theory," "statistical methods," or "statistical techniques." In an article in the November 1953 issue of Advanced Management, entitled "Management's Responsibility for the Use of Statistical Techniques in Industry," W. Edwards Deming makes the following observation on statistical theory:

> "The basic theory and statement of principles are the same for all problems. This is why a small amount of theory, well-learned, is such a powerful tool. No other body of principles taught in school has wider applicability, nor can contribute more to the modern industry."

Continuing his introduction of this new tool to management, he makes this further observation:

> "Schools of engineering, commerce and business administration should teach statistical theory, not as an end in itself, but from the functional angle of power in the solution of man's problems."

This is a sound advice, indeed, because as he points out later, statistical methods are not just a group of techniques or the accumulation of a mass of data and figures but a new mode of thinking which can be converted into positive action. The rapid expansion in the use of statistical methods during the past

fifteen years and its continuing expansion in the future depends on the extent to which industry develops a staff of statistically minded engineers, production supervisors, industrial accountants and management personnel. Statistical methods assume their greatest importance and value when competition is keen, quality of materials and products must meet critical specifications and tolerances, and when a small variation from specification standards can result in large losses. Much of the guesswork can be removed from management decisions when these important decisions must be made on the basis of indefinite and incomplete data.

It is appropriate, therefore, that we review in this article the record of development in this new field of control and bring ourselves up to date on the diversified uses of statistical methods and techniques. Throughout this review, we can examine the role of the industrial accountant as a member of the statistical team of management as well as his new responsibilities which grow out of a program of statistical controls. Also presented are the experiences of my own company in adapting statistical methods to the control of its activities.

Statistics Makes Its Entry on the Industrial Scene

The development and application of statistical theory to industrial activity goes back to 1924. However, although there were some advances made during the early years, it was not until 1940 that the first applications in industry were noted in connection with production activities. The vast quantities of ordnance materials required at that time, target delivery dates set in government procurement contracts, and the high degree of perfection built into the specifications as a basis of acceptance, could not have been so successfully serviced without the use of statistical methods in product quality control and production programming. Shortages of critical materials accentuated the problems of the time. There could be little or no waste of critical materials through product rejects and there was no time for the re-working of materials that did not meet the rigid specifications. Precision and perfection of products and materials and high standards of quality and performance were vital factors, because the security of our country and our armed forces were dependent on them.

The initial industrial application of statistical methods was in the field of acceptance sampling and quality control. The sampling inspection of vast quantities of materials and products through the use of mathematically sound statistical acceptance sampling procedures proved to be not only adequate in meeting the test but also, in most cases more accurate than a 100 per cent sampling inspection procedure. With respect to the latter there is always present a

factor of fatigue which impairs judgment of the inspectors and results in human bias. This factor is eliminated when statistical methods are used as the basis of quality acceptance.

It was natural that this success in the first full-scale use of statistical methods in this limited area should be continued and then expanded to solve many other problems of production. Wherever statistical acceptance sampling was in use, businessmen in organized groups began to study the possibility of making greater use of this new tool which has helped solve critical problems and severe demands during the early 1940's. In 1946 the American Society for Quality Control brought these individual groups together in a national organization dedicated to the advancement of statistical methods in the solution of industrial problems.

To meet the need for a fundamental training in statistical theory and its functional use, separate and apart from the more complex mathematics on which the statistical methods were built, some short intensified courses were established for business management personnel in a few universities. The first record of these short courses indicates that they were initiated by Stanford University. These were intensified courses and usually covered a period of only eight to ten days. During this short period of indoctrination, management men could acquire a working knowledge of the basic principles and objectives of statistical methods as applied to industrial problems. This activity has spread across the country and many colleges and universities now include either part-time or full-time courses of this type to supplement their regular curricula in engineering, commerce, economics and statistical mathematics. In this area of growth, we can see that recognition has been given to the fact that "a small amount of theory, well-learned" is a powerful tool and that statistical theory is valuable to industry when taught from its functional angle. Although this basic type of training does not take the place of the teaching of mathematical statistics, it does make possible a much greater and diversified use of statistical theory through practical applications in the solution of production problems and in the field of business forecasting.

Applications Unlimited

It would be difficult to list all of the uses and applications which have been made of statistical theory, methods, and techniques, now found in almost every type of business, large and small, in every section of the country. It might be said that statistical theory has had an impact on "every human activity in production, business, government and research." Although the procedures are gen-

erally referred to as "quality control," this reference does not restrict the field of use to the acceptance quality of a product or a material. The reference to quality is applicable to our every activity. It refers equally to the performance of machines, the quality or accuracy of a forecast, the soundness of an operating schedule, the use of manpower and machines at maximum levels of efficiency, the soundness of a program of auditing verification of clerical transactions, the test checking of inventories, and an almost limitless list of every day activities.

In the management field, statistical methods can take the guesswork out of forecasts to a major degree. We can predict future trends with greater assurance that the proper weight is being given to all inter-related factors, without having to make hazardous projections of each individual factor. Instead, we can make simple calculations to reflect the effect of variations in one or more of the factors in relation to all of the other factors in the problem being studied. The feedback effect of variations in alternative approaches can be measured in the simple procedures which have been developed. It is now possible to make meaningful projections of sales and then develop a supporting program of production, shipments and inventories at optimum levels. The statistical approach can be used to quickly and simply solve the problems of forecasting when such factors as product-mix, class and type of customer, seasonal trends and many other complex elements are present. In short much sharper decisions can be made by management.

In production activities, through-put can be increased, rejects and waste of materials can be reduced, utilization of materials can be improved, greater uniformity and quality of end product can be accomplished, and costs can be reduced. All this is possible with our present equipment and without plant expansion.

In the field of purchasing raw materials and supplies, we may now establish adequate standards of acceptance and may apply sampling procedures which will make certain that goods subject to adverse quality variations will not enter our plant and unfavorably affect our entire processing operations. Perhaps suppliers will be inspired to use statistical methods, resulting in their further spread.

In the field of accounting and auditing many applications have been reported, such as the test checking of invoices, pay-roll calculations, inventory verification and in many other clerical activities in which the volume of work is very extensive. In an article by Howard M. Daniels entitled "Improving Controllership Through Probability Statistics" in *The Controller*, March 1954, it was noted that some thirty railroads had met to discuss the scientific sampling through the use of probability statistics, of waybills as a basis for making inter-

line settlements. This statistical method would replace the auditing and handling of a vast number of individual waybills. It was also reported that the Plomb Tool Company has used statistics to control over-time work and that the Illinois Bell Telephone Company has used statistics in the verification of clerical work. This quick citation of reported uses, taken from sources which report many more, indicates rather definitely that statistics has a recognized place in the accounting office, as well as in the industrial plant. Applications have also been made in connection with appraisals of industrial and utility properties and in the study of replacements of equipment. Statistics have been used to advantage and in developing maintenance programs in the control of maintenance costs. The frequency and servicing of equipment in a preventive maintenance program can be determined with greater accuracy through the use of statistical methods. Alternative uses of machines have also been decided by statistical projections.

The program of the Eighth Annual Convention of the American Society for Quality Control in 1954 included the presentation of sixty-six papers and each application reported was distinctive, although the "principles are the same for all problems." The authors represented a broad segment of management personnel and industry and included college professors, specialists in statistical mathematics, statisticians, quality control supervisors, sales managers, production supervisors, works supervisors, and men from almost every level of management. The fields of interest and application appear to be unlimited. In line with this it may be said that there is little doubt that successful use of statistical methods in any business depends on a well-integrated management team trained in statistical thinking. This team must include representatives from every level, from top management all the way to the front-line management and operating personnel in the plant. Each level of management must acquire an understanding of statistical theory in relation to its functional use in the control of quality and costs.

Four Levels of Understanding of Statistical Techniques

E. L. Grant, in his book "Statistical Quality Control" (McGraw-Hill Book Co., 2nd Edition, 1952), lists four levels of understanding in the field of statistics. A discussion of these four levels of understanding is presented here to bring into focus the contributions made by each level to the growth and development of statistical methods and techniques. The first is the level of understanding of the mathematics on which the control charts and tables, as well as other statistical tools, are based. In this essential field, we find the mathematical statisticians. In this group are the men who have worked out the complex formulas

and mathematics which are the foundation of statistical methods and techniques which have been applied so successfully to the problems of industry. This is a limited field and the industrial management man can "leave the mathematics to the mathematical statisticians." Men like Grant, Deming, Shewhart, Dodge and Romig have developed techniques and designed methods of application in simple terms for use by industry.

The second level is that of general understanding of the basic principles on which the control charts and tables are built and the applications which can be made to our problems, as well as why these methods work and how to interpret their results. At this level we need a knowledge of the functional applications of statistical theory. The books which have been written and the courses offered by many universities and colleges can bring us the fundamental knowledge we need to make a start in the application of statistical methods in our own businesses.

The management level, usually senior management, is the third level of understanding and is the one at which there should be a broad knowledge of the many possible uses of the methods and procedures and their objectives. As with any other significant activity, it is important that full cooperation and backing be had at top management levels. As pointed out, success depends on developing a statistical-minded team representing every level of management and every activity in the business. Although an initial application of statistical methods may be confined to a limited area, it usually expands into many other areas of activity and it is sound advice to have the entire staff trained in statistical thinking.

The level of acceptance, cooperation and comprehension—related to statistical techniques—within the plant by inspectors, production workers and statistical clerks, forms the fourth level of understanding. At this level we find the people who assemble the source data and prepare the charts which signal corrective action when it is indicated by the data plotted. It is necessary that this group, too, have a fundamental knowledge of why and how the methods work and the benefits which can be gained through their application and prompt action when it is indicated.

It is only at the first level that the mathematics underlying statistical methods must be mastered. At all other levels, we need only fundamental knowledge of the methods and their objectives in order to initiate a program of statistical evaluation and control. Once started, growth and expansion is inevitable as knowledge and experience grow. Once we understand and have tested the power of this new tool, we just naturally set out to survey and study all of our varied activities to find the most likely spots to expand the applications.

We Chose a Team and Began to Study

When we initiate a program of statistical methods for a business, we preferably do not design an all-inclusive program for all activities and then try to install the "new procedures" all at once. The better approach is to select one area in which variations have resulted in some lack of control of quality or in obvious lack of control of costs. Here we plant our first seed. We plan statistical control procedures for the situation, make the necessary initial survey of present performance and costs, track down all assignable causes of variation during the survey, put our equipment in top condition, establish control limits, and then begin to take the action necessary to bring our activities into control and keep them there.

This first application might be described as experimentation. It is not necessary to have a long recorded history of operating costs and trends to initiate statistical control procedures. By using the experimental approach, we can acquaint ourselves with the new control tool. We can acquire experiences in planning and putting the program into use and set the pattern for future applications. In this first experiment or exercise, we can acquire confidence in the ability of the new methods to control production activities and can learn to recognize and interpret the signals given by control charts when corrective action is indicated as a process begins to move out of control.

The following pages summarize the recent entry of my own company into the field of applied statistical control. The approach just described has been taken and it is interesting to note how the application has already begun to expand into the other areas of activity. It was decided that, rather than secure professional services from outside the company, we would move slowly into this new field of control, developing our own staff men as we progressed. In this way we would develop a better understanding of the problems and objectives and each member of our staff would be better able to evaluate his action and decisions in relation to the effect it would have on the program as a whole. We chose a team representing production planning, production supervision, cost control and statistical reporting, and technical control and engineering functions. The various levels of management were all represented.

With the help of some good text books and other literature, we undertook a program of self-education in statistical methods and reviewed many case histories in which successful applications has been made. This program of preliminary study and round-table discussions was supplemented by attendance at meetings of a section of the American Society for Quality Control. One of the

faculty members of a local university helped us to bridge the gap between the complex statistical mathematics and the simple calculations and formulas which are used in the methods developed for industrial use. The next step was to have a qualified cost analyst from our accounting staff, who was a member of the team, attend one of the short courses offered by Marquette University in Milwaukee. He was able to acquire that "small amount of theory" which has been so valuable to us as a guide in this new venture. We have learned that it is quite true that, after only a few sessions in an intensified course, a capable cost or statistical analyst is able to undertake the first on-the-job experimental applications of statistical methods which set a program in motion.

Our First Application: Net-Contents Weights

The team then set up a basic or preliminary program in general terms and selected the area in which the first test run would be made. When this was done we added a few more members to the team. Production men, check weighers, and statistical clerks were instructed in the procedures and their objectives. Although there are many areas in our refining activities, in both production and distribution, which should react very well to control by statistical methods, we picked the one in which there were the greatest number of factors susceptible of causing variations from established standards of performance. This area was our refined sugar packing center which had just recently been housed in well-planned and engineered air-conditioned quarters and all packing machines units transferred and re-installed. Much of the machinery in this section is fully automatic and operated at high speeds. Yet, although we had devoted a great deal of effort to the problem, we had not been able to bring the efficiency of all units up to rated capacity, or expected percentages of rated capacity, of throughput. We had, nevertheless, accumulated some current information on hourly and shift production out-turn for each packing unit separately. We had recorded all stops and down-time, giving the reason for the lost time. The assignable causes of lost time had been classified and coded with emphasis placed on mechanical failures and the frequency of stops for scale adjustment to maintain proper package-fill weights. A record had been kept on each shift of all damaged bags and containers, which were accumulated and subjected to critical examination to determine whether damage was caused by machine failure or the quality of the container, itself. A record had also been kept of the number of under-weight packages which had to be rejected and the time spent in the 100 per cent sampling and check-weighing of these lots to establish a record of scale performance.

Here we found the logical place to initiate the first statistical methods of control undertaken by my company. A very small over-fill tolerance can account for a very large dollar value of sugar given away to insure compliance with weights and measures laws, particularly when this over-fill has been set high enough to compensate for scale performance variability. This compliance involves Federal and state regulations relating to the maintenance of marked "net-content" weights by food manufacturers and packers. To be on the safe side, many food packers set their scales to provide a small percentage of over-fill, and let the matter rest there. However, with high speed automatic machines there can be wide variations in scale performance and, unless this over-fill tolerance is set relatively high, it is still probable that under-weight units will be released.

We pack several grades of refined sugars in a number of sizes and types of containers. The range of package sizes includes two, five, ten, twenty-five, and one-hundred pound bags and one pound cartons. The grades include various grain sizes of hard refined sugars, confectioners powdered sugar and three principal grades of soft refined sugar. All of the packing machine units are either fully, or to a high degree, automatic and scales operating at high speed are extremely sensitive. This fact in itself, constitutes a source of many possible variations from standard performance. Approximately 61 million individual units are packed annually. Thus the problem of maintaining net-content weights and, at the same time, keeping the over-fill tolerances to an absolute minimum, was of sufficient importance alone to justify an experiment in the use of statistical methods of control.

On the basis of the information developed by our cost control staff, many things were obvious. Frequent stops had to be made to adjust scale performance. Percentages of downtime for other mechanical adjustments was relatively high. The percentage of bags damaged varied as among similar packing units and the over-all loss had been rising. The frequent starting and stopping of these sensitive automatic machines had made a substantial contribution to their inability to stay within normal ranges of control for any length of time. It was obvious that statistical control limits and ranges could not be established until we knew the capacity of our packing machinery to operate at normal levels of volume, for reasonable time periods and without adjustment. Procedures to activate the program were planned and written, the personnel assignments made and detailed instructions given. At least two initial test and check runs would be made on each of the packing machine units, the first to determine the present capability of the unit and to ascertain all assignable causes of variation in the

process the second or check run to re-evaluate performance of the unit after the engineering department had put the machine in top operating shape.

The Shewhart control chart for averages and ranges and recommended statistical sampling procedures were adopted to record data on both initial runs. The Shewhart technique was adopted because it provides for segregating assignable causes of variations in quality or process performance. The data charted on the first run cannot be used in setting ultimate prime limits for control, but it does provide a very accurate picture of where the trouble is and where correction is needed. The data on the second run will usually give an accurate indication of the natural tolerance range of the unit surveyed and becomes a basis for the setting of prime control limits. Before start of the first test run, it was necessary to verify the accuracy of the check-weight scales with certified weights. Container weight (tare) had to be established on the containers to be used in the test and check-scales adjusted to reflect this accurate tare weight. There was measurable variability in the weight of containers and the actual unit weight of each lot used had to be established for each run.

Recording of Data and Plotting of Charts for the First Test Run

The data sheets and control charts make use of a number of symbols in identifying the information tabulated and used in construction of the charts. The symbols employed by us are those in general use, although not fully standardized, and they establish a common language for presenting statistical control information. An explanation of the symbols used in this paper is necessary to permit better understanding of the matter presented. The book by E. L. Grant already cited lists these symbols as follows:

X a number representing a value of some variable; in statistical quality control, X is usually the observed value of some quality characteristic for an individual unit.

$\overline{X}$ (X bar), the average (arithmetic mean) of two or more X values.

$\overline{\overline{X}}$ (X double bar), the average of a set of $\overline{X}$ values, sometimes called the grand average.

$\overline{X}'$ (X bar prime), an aimed-at or standard average value of a quality characteristic.

UCL upper control limit on a control chart. $UCL_{\overline{X}}$ refers to the upper control limit on an $\overline{X}$ chart.

R the range, i.e., the difference between the largest and the smallest value in any set of numbers.

$\overline{R}$ (R bar), the average of a set of ranges.

UCL_R the upper control limit on a chart of ranges.

The values or factors used in determining the indicated or prime control limits in the calculations which are made are also taken from Grant's book. This table of factors is presented, in part, below:

Factors for determining from R, the 3-sigma control limits for X and R charts

Number of Observations in sub-group n	Factor for X chart A_2	Factor for R chart	
		Lower control limit D_3	Upper control limit D_4
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00

Upper control limit for $\overline{X}$	$UCL_{\bar{x}}$ equals $\overline{X} + A_2\overline{R}$
Lower control limit for $\overline{X}$	$LCL_{\bar{x}}$ equals $\overline{X} - A_2\overline{R}$
Upper control limit for R	UCL_R equals $D_4\overline{R}$
Lower control limit for R	LCL_R equals $D_3\overline{R}$

The table of factors used in the development of control limits for average and range charts is based on a normal distribution in the sample and the limits for averages encompasses three sigma deviations above and below the grand average which the process can maintain. The limits reflect the effect of the range between the highest and lowest value in the sample. The tables, and the limits developed through their use, give us the assurance we need, that, when a process is brought into control and (with few exceptions) average samples fall within the control limits, our level of quality will be approximately 99.7 percent acceptable.

Exhibit 1 is a tabulation of the control data accumulated on the first test run of a 100 pound valve-pack machine and covers a portion of the entire run, which was continued through two complete shifts. The characteristic of the measurement was the filled container and the variance above or below the net content weight (100 pounds) was recorded in units of ¼ ounce. The sample size was set at five, consisting of five consecutive bags taken at twelve minute intervals. Each sample was recorded by individual measurements and the average developed for each sample. This is referred to as $\bar{x}$ on the data sheet. The range, or difference between the highest and lowest value in the sample, is also recorded and referred to as R on the data sheet. The average of each sample and the range are plotted on an average and range chart as the test progresses. At the end of each shift a grand average ($\overline{X}$) of the sample average ($\overline{X}$), and the average range ($\overline{R}$) are computed.

MACHINE CAPABILITY TEST RUN No. 1 (Part 1)

8 A.M. to 12 Noon

Filling Machine #1390 Product: 100# Extra Fine Granulated – Valve Pack
Exact Weight Check Scale #4 used in test
Characteristic of Measurement: Weight of filled bag – variations over or under 100# content recorded in 1/4 ounce units

Time	Sample readings: 1/4 oz. units Five consecutive packages					Sum of Sample	Sample Average ($\bar{X}$)	Sample Range (R)
8:12	5	7	-11	7	-1	7	1.4	18
8:24	8	0	2	9	4	23	4.6	9
8:36	0	0	0	-2	4	2	0.4	6
8:48	-5	2	-2	0	-6	-11	-2.2	8
9:00	8	-1	-9	9	-6	-4	-0.8	17
9:12	7	8	43*	4	-13	49	9.8	56
9:24	-7	-9	-10	-6	-5	-37	-7.4	5
9:36	-3	-5	-7	-9	-5	-29	-5.8	6
9:48	-2	4	-2	1	-3	-2	-0.4	7
10:00	1	-2	0	3	30*	32	6.4	32
10:12	4	-7	5	32*	8	42	8.4	39
10:24	1	9	5	10	-2	23	4.6	12
10:36	4	4	11	20	7	46	9.2	16
10:48	-4	-4	-12	5	-14	-29	-5.8	19
11:00	-9	-10	10	-5	7	-16	-3.2	17
11:12	-2	-10	6	-3	1	-8	-1.6	16
11:24	27	-14	-4	8	16	33	6.6	41
11:36	6	-2	6	-12	-4	-6	-1.2	18
11:48	-3	2	3	8	7	17	3.4	11
12:00	3	42*	3	6	3	57	11.4	39
Totals							37.8	392
Sample grand average & average range							$\bar{\bar{X}}$ 1.9	$\bar{R}$ 19.6

*(Filler gate failed to close)

Indicated (calculated) results:

$\bar{\bar{X}}$	1.9	$\bar{R}$	19.6
UCL$_{\bar{X}}$	13.3	UCL$_R$	41.4
LCL$_{\bar{X}}$	- 9.5	LCL$_R$	0

(See text for calculation of limits from control data)

EXHIBIT 1

Exhibit 2 is the control chart projection on the first stage of the initial run and, on the basis of the information tabulated on the data sheet, we also plot the average quality for the run. It will be noted that, in spite of the obvious lack of control, an average of 1.9 units over-weight (1/4 ounce units) was indicated for the entire lot produced. However, reference to Exhibit 2 shows conclusively that there is a wide variability in the weights, with a large percentage falling both above and below the prime weight (100). This is also confirmed by the erratic pattern of the range, which developed a range of 19.6 units (average) for the run. During this initial run, the machine was allowed to operate without adjustment and the entire run was critically observed by a maintenance engineer who noted assignable causes of the variations. On the basis of this study, the over-haul of the unit was planned and it was then taken out of the line for repairs.

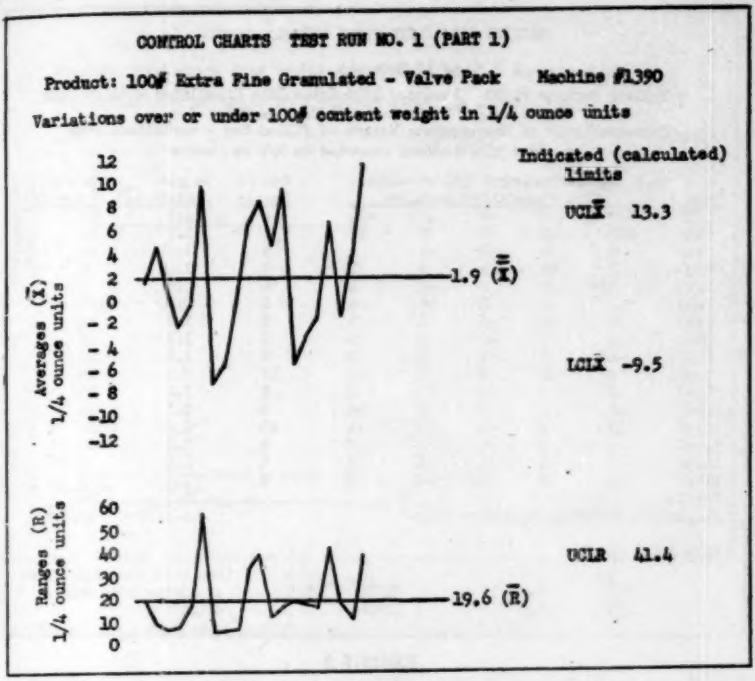

EXHIBIT 2

Using the grand average ($\bar{\bar{X}}$) of 1.9 units, the range average ($\bar{R}$) of 19.6 units, and applying the factor taken from the table of values applicable to a sample size of 5 (A2 or 0.58; D_4 or 2.11), we can calculate the "indicated" upper control limit ($UCL_{\bar{x}}$) and lower control limit ($LCL_{\bar{x}}$) for sample averages and the upper control limit (UCL_R) for the ranges. These indicated limits are calculated as follows for the test run:

Averages:
Upper control limit: $\bar{\bar{x}}$ plus $A_2\bar{R}$
1.9 plus (0.58 x 19.6) equals + 13.3 units
Lower control limit: $\bar{\bar{x}}$ minus $A_2\bar{R}$
1.9 minus (0.58 x 19.6) equals — 9.5 units
Range:
Upper control limit: $D_4 \times \bar{R}$
2.1 x 19.6 equals 41.4 units

The development of these indicated limits for the initial test have no practical use in setting future limits after the process is brought into a reasonable

MACHINE CAPABILITY CHECK RUN

4 P.M. to 12 Midnight

Filling Machine #1390 Product: 100# Extra Fine Granulated - Valve Pack
Exact Weight Check Scale #4 Used on Check Run
Characteristic of Measurement: Weight of filled bag - variations over or under 100# content recorded in 1/4 oz. units

Time	Sample readings: 1/4 oz units Five consecutive packages					Sum of Sample	Sample Average ($\bar{X}$)	Sample Range (R)
4:30	10	10	-6	10	-10	14	2.8	20
5:00	-10	10	-6	0	12	6	1.2	22
5:30	4	6	-2	-4	1	5	1.0	10
6:00	2	-2	4	2	1	7	1.4	6
6:30	2	2	0	-4	4	4	0.8	8
7:00	2	-2	0	0	4	4	0.8	6
7:30	6	-4	-6	6	6	8	1.6	12
8:00	4	6	-6	2	0	6	1.2	12
8:30	-4	6	-2	6	2	8	1.6	10
9:00	2	-10	8	6	4	10	2.0	18
9:30	2	6	1	-4	2	7	1.4	10
10:00	10	4	2	-6	-2	8	1.6	16
10:30	10	6	-4	2	-4	10	2.0	14
11:00	-4	0	6	2	2	6	1.2	10
11:30	2	4	1	-4	2	5	1.0	8
12:00	-6	10	2	-2	4	8	1.6	16
Totals							23.2	198
Sample grand average & average range							$1.5(\bar{\bar{X}})$	$12.4(\bar{R})$

Calculated results:

$\bar{\bar{X}}$	1.5	$\bar{R}$	12.4	(See text for calculation
UCL$\bar{X}$	8.7	UCLR	26.3	of limits from control
LCL$\bar{X}$	-5.7	LCLR	0	data)

EXHIBIT 3

pattern of operating tolerance, but they add confirmation as to the extent of variability and are useful in the interpretation of the data. They also establish present level of process efficiency, which will be used in measuring our progress and ability to improve the operation. In obtaining these first run results, the recording of information on the data sheets and the plotting of the information on the control charts was done by the check weighers under the supervision of the cost analyst, who had been trained to become our first quality control supervisor. Interpretation of the information was then undertaken by a team including the packing center superintendent, quality control supervisor and a representative from the engineering department. It is interesting to note that our first quality control supervisor was a man from our cost accounting department and that he is still under the supervision of that department. We feel that this is important, because any decisions made in connection with this program must rely on the accounting evaluation of the benefits to be gained in relation to the cost of extended control.

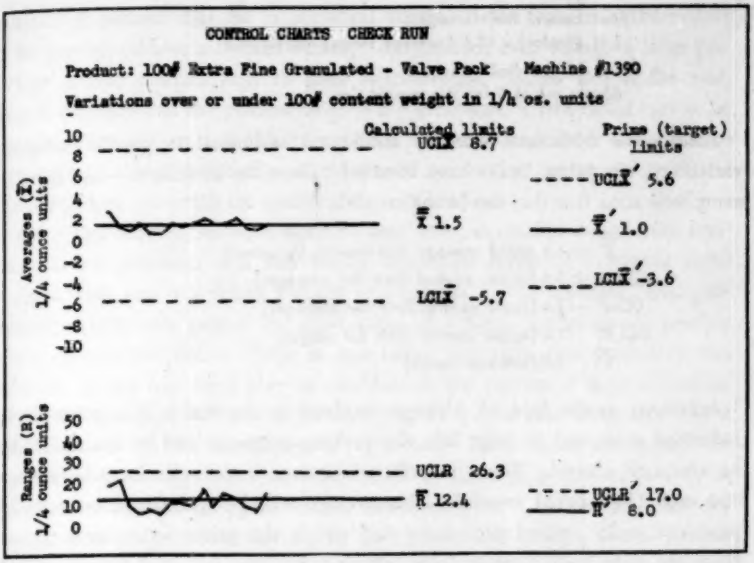

EXHIBIT 4

The Check Run to Establish Operating Control Limits

The second, or check run, made after the packing machine unit has been completely overhauled, follows the same pattern of sampling, recording of data and plotting of averages and ranges, except that this second run used a sampling frequency of thirty minutes as compared with twelve minute frequency on the test run. Frequency of sampling can be reduced as a machine is shown to be capable of running for extended periods within control limits and without adjustment. Exhibit 3 is the tabulation of sample averages, ranges and the grand average for the check run. Using the formula for establishing indicated control limits previously described in connection with the first run data, we can now develop limits which can be used as a guide in setting "prime" limits or the goal we will try to reach. Exhibit 4 is the control chart projection based on this new data. The results are:

Calculated limits:

Upper control limit—averages:
1.5 (grand average) plus (0.58 factor x 12.4 average range) equals + 8.7

Lower control limit—averages:
1.5 (grand average) minus (.058 factor x 12.4 average range) equals — 5.7

Upper control limit—ranges:
2.11 (factor) x 12.4 (average range) equals 26.2
Lower control limit—ranges:
Always set at 0 for this sample size

After some additional work to eliminated additional assignable causes of variability, our prime limits have been set. These are as follows—and there is every indication that they can be maintained:

$\overline{\overline{X}}'$ + 1.0 grand average unit overfill, ¼ ounce)
UCLx' + 5.6 (upper control limit for averages)
LCLx' — 3.6 (lower control limit for averages)
UCLR' 17.0 (upper control limit for ranges)
$\overline{R}'$ 8.0 (average range)

Inasmuch as the type of package involved in the run is sold primarily to industrial users and in large lots, the packing operation can be assumed to be in adequate control. There is sufficient assurance that the lot will average one unit (¼ ounce) overfill. This average will be maintained on each lot produced under control procedures and within the prime limits, even though there are some individual samples falling below one hundred pounds. There has been marked improvement in the process, as a result of statistical methods, in finding and removing the causes of variability.

In the packing of consumer size units, the net weight of each bag becomes important because these units are sold to the householder individually and not in large lots. The Federal and state regulations fix our primary lower control limits and individual units having a net weight of less than their marked content weight will not meet the requirements. Therefore, the problem is the maintenance of an average overfill at the very lowest minimum within the capability of our equipment. A close or critical balance must be kept between the cost of control and the cost of the overfill tolerance. After we have determined the capability of the consumer filling and packing units and established control limits, we can then adjust the overfill so the average, and the entire process limits, are moved to a point at which a negligible number of units will fall below the 0 (zero) limit line or marked content weight.

Normal Distribution and Statistical Control

Use of the table of values in calculating the process average and upper and lower control limits is based on the assumption that there is normal distribution reflected in the samples and the process, which is the result of "chance

causes." A process may be in statistical control if the pattern of variability in the process follows a normal curve of distribution, even though a large percentage of the product fails to meet specifications. When this is the case, there is evidence that the process range is too great and, if this factor cannot be corrected, then we are not able to produce products which meet the specifications without a high percentage of rejects. It means that the capability of our equipment does not match the specification requirements.

In our case studies, we have assumed that, after assignable causes have been removed, our processes will fall within reasonable limits of a normal curve of distribution and will reflect a range or dispersion of the universe (total production) which will permit the production of a high percentage of product within specification limits. Even in our initial test runs, this possibility was indicated, as we had been able to establish in the successive tests a level of process average that followed a constant pattern. After the assignable causes were removed, we then established a performance level which was susceptible to statistical control and our attention could be directed to the narrowing of the range which was indicated in our check samples. The control chart for averages would signal any shifting in the process and change in the process dispersion (which is also reflected in the ranges). When a process begins to shift or move either outside the control limits or within the control limits, there are some rather simple rules which can be followed. For example, if seven points are plotted above or below a prime limit or average line, there is evidence that the entire process has moved to a higher or lower level of performance and this is a signal to begin to track down some new assignable cause. The shift in process may reflect a change of operating level for the process as a whole or may be the result of a change in the range without affecting the process average. These interpretations from charted data help us in finding and correcting the causes before major trouble develops.

Some Specific Assignable Causes of Variability

In addition to many assignable causes of variability which can be observed in process machinery performance, there are some which we may overlook. There can be considerable variability in the performance of the mechanical equipment which we use to check the mechanical performance of the machines, themselves, such as the check scales. There can be variability in the ability of check weighers to read scales correctly. So that these causes will not become buried in the composite process variability as charted, we also run control charts and make test check of these two additional contributors of variability.

For these purposes, we make frequent samplings of performance of check-weight scales, using certified weights, adding and deducting small fractions of weight, and observing readings on scales. We also make regular checks on the weighers and run a series of readings periodically. To do this, we use a scale which has just been checked with certified weights and then require check weighers to read the scale dials while a supervisor changes weights on the scale pan. In this way, we can compare the readings with the weights used and determine the ability of the operator to read these dials within very close limits and ranges. Control charts have many uses.

Expanded Application of Statistical Methods Inevitable

It is quite true that, once we have begun the use of statistical methods of control, there is no turning back. We have extended their use to the acceptance sampling of containers and other materials. This has led to the development of very definite specifications for our containers and, in this field of application, we have experienced a marked decrease in the percentage of damaged containers. Much of the prior damage was traced to the quality of the containers rather than to mechanical failures. The elimination of containers with slight defects which cause malfunctioning of the automatic bag feeding magazines has removed another cause of lowered efficiency of through-put.

A team including representatives from the technical and research control laboratories has begun the studies of possible application of statistical methods to many flow-process stages of the refining operation. The quality of raw sugar melt liquors, cycle time of centrifugal washing, mingler temperatures, granulator in-put and out-put temperatures, bone-char grain size and filter flow rates, and many other factors are being made the subject of statistical control. We have made very good progress in the development of a statistical minded staff in every department.

Statistical methods are also being used in studying and forecasting trends in demand, the development of operating schedules at optimum levels, the projection of inventory requirements and other vital factors required in our budgets and forward forecasts. We have become acquainted with the power of statistical techniques in decision-making and, as our experience grows, so will our ability to find and expand its use.

The use of statistical methods and techniques in industry is a relatively new development. The number of text books devoted to industrial applications are limited and the greatest amount of information on the subject is included in papers such as this. For the present, the spreading of information on the

use of this new and powerful tool will continue through that media. There is also some evidence that many colleges and universities are including short fundamental courses as part of their regular curricula and this will help the business man acquire that "little bit of theory" he needs to make an all important start toward many new efficiencies. The cost and industrial accountant can greatly expand his service and value to management by becoming proficient in this field. In our company our accounting staff, and particularly the cost analyst (who becomes quality control supervisor), have made a very valuable contribution to the success we have had thus far in our first experiments in the use of statistical methods. Members of the staff have taken on new responsibilities and in the future their job will be the maintaining of an economic balance between the cost of control and the savings which are anticipated. They can also add a very valuable contribution to the detail work during the early stages of the program. It seems inevitable that the industrial accountant must become acquainted with statistical methods and techniques and take his rightful place on the management team.

Work Sampling is Procedural Trouble-Shooting

by CHARLES G. WHITE

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Reserving for the closing section of the article a compact explanation of the practical mathematics involved, the author of this article explains work sampling (or ratio delay) and presents it as a mathematical-statistical tool of engineers applicable everywhere it is desired to locate, identify and control causes of delays or, more broadly, impediments to efficient operation, whether mechanical or procedural.

WHAT IS WORK SAMPLING? Briefly defined, it is a random sampling method of observation to get more information about any activity than it is practical to get by continuous observation. It enables management to get facts without watching everything and everybody all the time. It gets these facts on product quality, machine operation, and human-activity. The first named area of application is by far the best known and most widely used. It is the basis for statistical quality control. The second application, to gather data about what machines are doing and why, is used by a handful of companies. Its most common name is ratio delay, because most of the use has been to find the ratio of various kinds of delays in machine operation to the total time. The third application, to analyze what people do while at work, is in its infancy. The few cases of this application have usually also been called ratio delay, because the technique was borrowed from machine-downtime studies.

Ratio delay is a method of finding by random observations the causes of delays in a particular area of activity and the ratio of those delays to total time. If we want to find out how much time a selected machine spends on operation, set-up, maintenance, and delay, respectively, using the ratio-delay technique, we observe the machine a pre-determined number of times a day, say ten. That does not mean an observation every forty-eight minutes during an eight-hour day. That would not be random sampling. We want ten random samplings during the day. They must follow no set pattern. For each observation we record what is occuring at the instant. At the end of ten days, the record may read:

	Observations	Percent of total
Operation	60	60%
Set-up	18	18
Maintenance	10	10
Delay	12	12
Total	100	100%

The basic theory, discussed further below, is that the precentage distribution of the various elements, as they occurred during the random observations, tends to equal the percentage distribution which would be found by continuous observation. The key to the accuracy of ratio delay is in the number of observations. A greater number of observations provides a higher degree of accuracy. However, nearly all plant problems have a point beyond which greater accuracy of data is not worthwhile. In the above example, one-hundred observations may or may not be enough, depending on the accuracy required.

Basis and Uses of Ratio Delay

Ratio delay is based on the law of probability. It works because of the fact that a smaller number of chance occurrences tends to follow the same distribution pattern that a larger number produces. The simplest way to explain this phenomenon is by reference to tossing a coin. When you toss a coin, the result is one of two possibilities, heads or tails. The law of chance says you should get fifty heads and fifty tails in one-hundred tosses of a coin. That is the ratio of the average possibility. It does not mean it will come out that way every time. You may get a score of sixty-forty, forty-five-fifty-five, or some other ratio, but it has been proved that the law becomes increasingly accurate as the number of tosses increases. The percentage of possible error decreases. Another example of how the law of probability works is dice throwing. It is more complex than coin tossing because one throw of two dice has thirty-six possible results, instead of two. Thirty-six throws will tend to produce one 2, two 3's, three 4's, four 5's, five 6's, six 7's, five 8's, four 9's, three 10's, two 11's, and one 12. Note that I said tends to produce. Each series of thirty-six throws will not duplicate the pattern exactly, but the results get closer to the pattern (probability curve) as you increase the number of series of thirty-six throws. The percentage of error decreases.

Ratio delay works the same way. A small number of observations taken at random tends to follow the same pattern of distribution as a larger number. The largest number would be continuous observation. Ratio delay has not yet been used on every type of problem for which it is suited. Old and new areas for it are easily exemplified. Continuous time study takes a lot of specially trained manpower but you must have factual data to establish reasonable allowances. However, you can get the same data by ratio delay in only a fraction of the man-hours needed to make continuous time studies. Ratio delay is also helping companies iron out production problems caused by inexperience with the new equipment. In the office, one observer can study a large group of clerks

simultaneously. A company adapted ratio delay to the analysis of clerical work, called it "cycle interruption analysis," to find the relative amount of make-ready, do, and put-away time. Another company uses ratio delay to aid in work simplification. The company's tank fabricating department did not have time study or any other factual information about production operations. The company used ratio delay to spot the best opportunities for savings through better methods. Common work elements were listed and grouped as follows:

1. Make ready (receive instructions, read blueprints, and move materials).
2. Craft work (layout, fit, position, weld, clean weld, burn, grind and sheer).
3. Worker delay (relief periods, interruptions).
4. Shop delay (standing by waiting for another worker to perform his operation in a group job, walking, equipment delay).

It was found that two elements—standing by and position—accounted for more than a quarter of the man-hours. So the company concentrated its first methods studies on those two elements. That is usually the best way to get big gains fast.

Sundry other examples could be given. Ratio delay has been used to study the crowded conditions of elevators. Still another company used ratio delay to get a picture of the flow of material in a small-lot operation. The sampling technique was much easier and faster than summarizing the movement from route sheets. At this moment studies are being made of the activities of the engineers in some companies to see if they are doing a lot of non-engineering work. One of the objectives is to find out if one or more clerks can do some of the work engineers are now performing. There is no telling where ratio delay will be used next. One thing is certain. Plant managements will find it useful wherever the need arises for more facts and where those facts are difficult to obtain by traditional methods.

Preparing for a Ratio Delay Study

Although the foregoing explanation suggests that work sampling is relatively simple, many in management will not believe it in a five-minute introduction. Factory and clerical personnel will not "buy" a brief explanation, either. The best way to explain ratio delay is to use material like that which has been given here, setting forth the law of probability and illustrating it by the coin and dice method examples. When a ratio delay study is to be undertaken, the first requirement is to determine exactly what information is required. This can usually be done by making a preliminary survey, perhaps observing the operation for

a day to get a list of the operation elements. For example, if you are after the causes and amount of down-time on a machine, you will need to define all the possible causes. These preliminaries are much the same as the preparation for a time study. Also, clearly define and discuss with observers each element to be observed and recorded. This step is very important where two or more observers study the same operation. Without it they may not be consistent in what they call what they see.

There is no set form for recording observations. It will be best to design a form to fit each study. The number of observations to be made depends upon the nature of the operation to be observed, circumstantial limitations, and the total number of observations required. If it is a short-cycle, repetitive operation in which all the elements occur frequently, the observations can be spread out. If it is a nonrepetitive operation, or one in which some elements occur infrequently, it will be better to make more observations in a day. That improves the chance of getting all the details. As to circumstantial limitations, if you have just one observer and a long route to make one round of observations, you will have to make fewer observations in a day. For instance, a study of maintenance crews would probably make a long route for one observer. With regard to total observations required as related to a time limit for the study, if you need fifteen-hundred observations for desired accuracy in fifteen working days, you automatically need one-hundred observations a day.

The number of observations, as distinguished from frequency, depends upon how accurate you want the answers. A larger number of observations provides greater accuracy. Experience with ratio delay and a knowledge of the operation will permit a pretty fair "off-the-cuff" estimate. The results can be checked as the study progresses to see when enough observations have been obtained. The true basis is a mathematical method of pre-estimating the number of observations needed to give the practical accuracy desired. Most management people will not want to understand the fairly complicated mathematics involved —and they do not have to. The theory is the same as that used in statistical quality control. If you want to get one-hundred percent of the potential value of ratio delay, you will want to have some person around the plant who has an understanding of the mathematics. He can then give quick help in predetermining the number of observations to be taken and in interpreting how finely accurate the results are. He will need to watch the progress of the observations, too. Sometimes he may be able to tell, with great accuracy, that there is no necessity to take as many observations as originally planned. Or perhaps he may say that, to be safe, more must be taken. Most companies have

several engineers who are able to understand and use quickly the mathematics involved.

Information is not of much value unless applied to some practical purpose. All the ratio delay studies in the world will not do a bit of good unless effective use is made of the facts they supply. Two things may be done with the facts from ratio delay studies:

1. They may serve to set up goals and upper and lower control limits for production time and the major causes of delays. Check studies of shorter duration can then be made each month to see if delays are under control.
2. Armed with facts about what kind and how much delay exists, informed supervision, trained in work simplification, can and will develop better methods for boosting productivity.

The Mathematics of Work Sampling—A Technical Guide

When you use random sampling, you are dealing with two kinds of potential errors at the same time, deviation and statistical error. Both can be determined, but they depend upon one another and must be considered together. In every kind of measurement work, a certain tolerance is accepted. It is the economical thing to do. Random sampling is merely a way of measuring, so a tolerance is acceptable here. It is called percentage deviation. However, with random sampling, there is a chance that the result of our observations will be outside the percentage deviation (acceptable tolerance), even though the actual percentage composition of the total is within the tolerance. This is the probability of statistical error. Percentage deviation and statistical error are related through what is known as the "standard error of deviation." This standard error is expressed by the following formula:

$$x = \sqrt{\frac{p\,(1-p)}{N}}$$

in which: x equals the standard error
p equals the percentage occurrence of the element being sought, expressed as a decimal (i.e., write 75% as 0.75)
N equals total number of random observations

Notice that it is necessary (for purposes of the equation) to know the percentage occurrence of the element being checked before you can determine the accuracy of your observations. So, for the present, estimate this percentage before you start your sampling and guess the number of observations you will need. (Revision of estimates will be taken up.) Now substitute the estimated figures for p and N in the equation, and solve for x, the standard error. What does the solution signify? A complicated statistical derivation, which we need not bother

with, tells you that sixty-eight times out of one-hundred, the result of N observations will fall between p minus x per cent and p plus x per cent. This is known as the range of one standard error. If (plus or minus) x per cent is an acceptable tolerance, you know that the probability is that sixty-eight per cent of the time the random observations will reflect the fact (which was assumed at the outset) that the element being observed is within tolerance. Conversely, a false indication will result thirty-two per cent of the time.

That is just plain not good enough for most uses. Too much is left to chance. But, if we will accept twice the standard error as our tolerance, then there are only five chances in one-hundred of getting a false indication from N observations. For most applications, this is a reasonable chance to take. Here's why it is reasonable. There are only twenty-seven chances in 10,000 that N observations will vary from the actual percentage, p, by more than (plus or minus) 3x, or three standard errors. Let us see just what this means in practical terms. Take a simple situation in which you want to know the amount of downtime on a machine tool. You guess that such time is running about thirty per cent, but you want to be sure within plus or minus five per cent (that's your acceptable tolerance on downtime and it's five per cent of the thirty per cent, not five per cent of total clock hours for the machine). If we call element tolerance y, we have this simple relationship between element tolerance and the standard error (or tolerance as a percentage of the whole):

$$y \text{ equals } x \text{ or } x \text{ equals } yp \qquad \frac{}{p}$$

In this case, we would have x equals 5% or 30% or, x equals 1.5%

However, we know that we want to work with two standard errors, so that our chance of false results will be only five out of one-hundred. Thus, for purposes of the standard error equation, our x must be one-half of 1.5 per cent, or 0.75 per cent. We now know x and p in the original equation. So let us go back and solve it for N, the number of observations. We get:

$$N = \frac{p(1-p)}{x^2} = \frac{0.30(1-0.30)}{(0.0075)^2} = \frac{0.21}{0.00005625} = 3730$$

If we make 3730 observations and find that downtime occurs in between 1065 and 1175 observations (30 per cent plus or minus 1.5 per cent), we know that there are ninety-five chances out of one-hundred that our original guess was valid within the tolerance we agreed to accept.

However, suppose, instead, that, at the end of twenty-five hundred observations, we have made only five-hundred observations of downtime. That is only

twenty per cent. Where do we go from here? Start your calculations over by assuming p is twenty per cent and N is twenty-five hundred. Solve the standard error equation for x. You will find it is 0.80 per cent. But that is one standard error. We are using two, and that is 1.6 per cent. To convert that to "element tolerance," we divide it by our new p, or twenty per cent. We find that the range of ninety-five per cent accuracy is now twenty per cent (plus or minus), a tolerance of eight per cent. Not good enough—we wanted five per cent tolerance. So it is back to equation, using an element tolerance of five per cent, and p equal to twenty per cent. We now find that sixty-four hundred observations are needed to satisfy the original conditions. Before we get to sixty-four hundred, of course, we go through the mathematics again to see how we are coming out. That lets us make any necessary adjustments. It is what the mathematicians call the process of successive approximations. To see how it works in a different way, suppose that our first twenty-five hundred observations indicated forty per cent downtime. In that case, we would find the standard error to be one per cent. Two standard errors would be two per cent. And that is just exactly (plus or minus) five per cent tolerance of the element percentage of forty per cent. So we stop making observations.

In this case, we have been working with fairly large percentages. What if we had been going after elements which occur only a small percentage of the time? Or if we wanted very small tolerances? The easiest way to see what happens is to take our formula for element tolerance (x equals yp) and substitute it in the standard error formula which we have set up to solve for N.

$$x = yp$$

$$\text{and } N = \frac{p(1-p)}{x^2}$$

$$\text{thus } N = \frac{p(1-p)}{y^2p^2} = \frac{1-p}{y^2p}$$

First, keep in mind that y and p are always decimals smaller than one. Now, as p gets smaller, the numerator of the equation gets larger at the same time that the denominator gets smaller. So the number of observations needed for a given tolerance will increase rapidly as the percentage occurrence of the element decreases. As to the second point, when you tighten up on the tolerance, the required number of observations increases as the square of the allowed tolerance. That is, a tolerance of one per cent will require four times as many observations as a tolerance of two per cent.

Since industrial accountants seeking to employ work sampling will be working with two standard errors (ninety-five per cent accuracy) most of the time, here

is a formula that will give directly the number of observations needed for any given percentage occurrence and element tolerance:

$$N = \frac{4(1-p)}{y^2 p}$$

And here's a table of the required number of observations for some common combinations of percentage occurrence and elements of tolerance:

Percentage Occurrence	1% Element Tolerance	5% Element Tolerance	10% Element Tolerance
1%	3,960,000	158,400	39,600
5%	760,000	30,400	7,600
10%	360,000	14,400	3,600
20%	160,000	6,400	1,600
30%	92,000	3,680	920
40%	60,000	2,400	600
50%	40,000	1,600	400

Statistical Estimates of Aircraft Tooling Manhours

by ROY W. SMITH

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Given here are the categories of information, the steps for their development into formulae, and the use of these formulae, needed to work historical manhours and other relevant data into reasonable estimates for hours required to prepare basic and maintenance tooling for various models of airplanes. Despite some assumptions of mathematical knowledge, the article is serviceable to all readers for its presentation of a specialized cost-related application of statistical methods. A solution of a hypothetical problem is given.

AIRCRAFT TOOLING COSTS for production of a particular model of airplane are divided into two major categories: basic tooling, which includes all tool design and fabrication labor required to build a basic set of tools plus duplication necessary to meet the delivery schedule, and sustaining tooling, which includes all tool design and fabrication labor necessary to maintain the original set of tools and incorporate production changes. The purpose of the tool estimating formulae is to portray the most significant relationship discovered between tooling labor and other cost parameters experienced on past airplane models, for application in estimating tooling costs on future models. Use of the formulae presupposes that a new model will require the same relative mixture of techniques which was needed on prior models. Separate consideration should be given to any unusual departure in manufacturing methodology.

In the case described in this article, formulae for basic and sustaining tooling manhours were derived by extensive application of statistical methods to actual tooling history of five different airplane models and were adjusted for comparability among models. Underlying data included:

(1) actual reported tooling and production labor hours adjusted to include tooling and production labor for subcontracted sections of the airplanes,

(2) tooling labor hours for the respective prototype models,

(3) airframe weight,

(4) delivery schedules for each model.

Basic and Sustaining Tooling Hours Related to Production Hours

The first step in the analysis was plotting the total tooling manhours against production labor manhours for each model by airplane blocks (Exhibit 1) to obtain a graphic picture of the relationship between all tooling and production

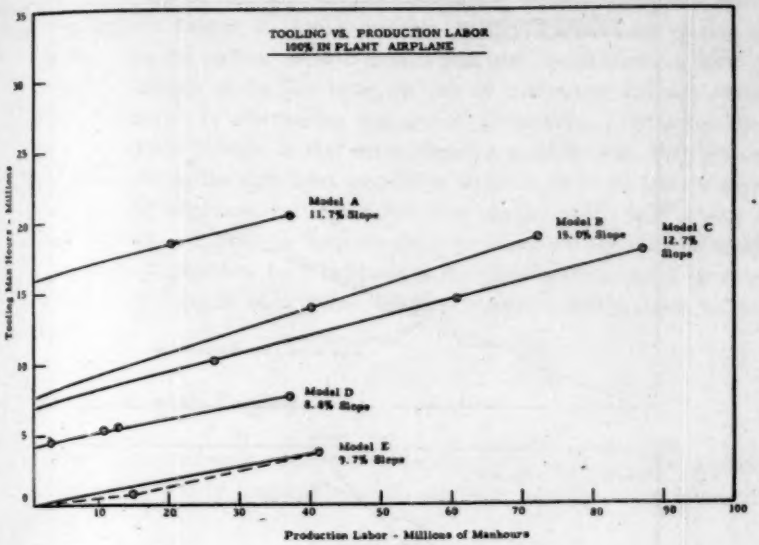
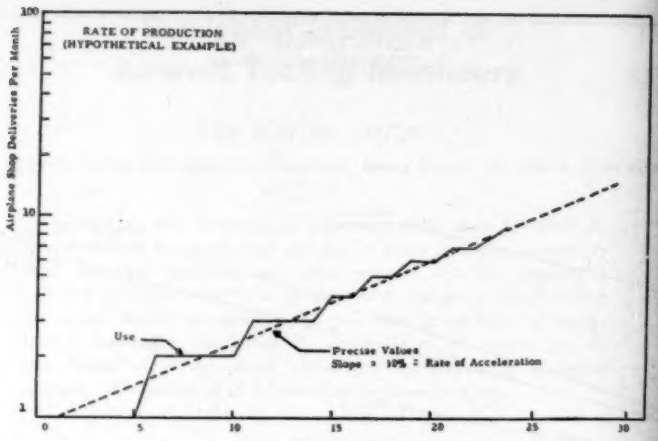


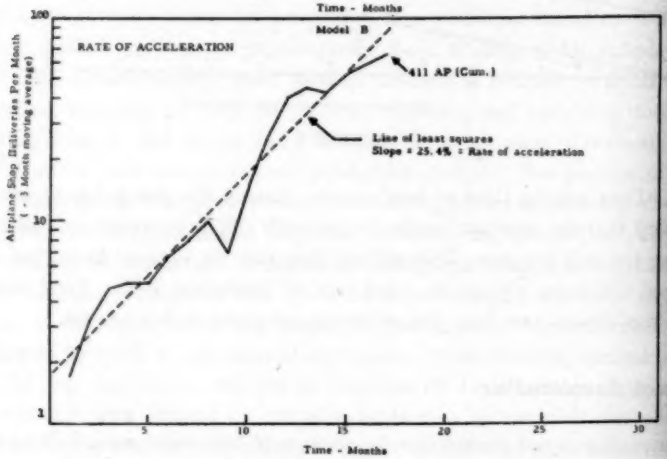
EXHIBIT 1

labor. Then passing lines of least squares through the plot points, it was established that the intercept on the tooling axis closely approximated the basic tooling for each program. This made it clear that the slope of these lines represented sustaining tooling as a per cent of production labor. Total tooling labor was divided into basic and sustaining categories in this manner.

Rate of Acceleration

Inasmuch as it was evident that the amounts of both basic and sustaining tooling are at least partly dependent upon the delivery schedule, it was necessary to develop a suitable index to measure the relative effect of the delivery schedule on these costs. Attempts using average deliveries per month and peak rate of delivery were not successful. However, the rate of acceleration of airplane deliveries per month did provide a good relative measure of the rate of production between programs. The rate of acceleration was developed using a curve of the compound interest type $Y = (1 + i)^n$, where Y is the number of airplanes delivered in any month, n is the number of months, and i is the rate of acceleration of deliveries. This curve appears as a straight line when plotted on a semi-log grid, with airplane deliveries on the log scale.





DELIVERIES PER MONTH AT 10% RATE OF ACCELERATION

No. of Months	Precise Value	Use	Cumulative Deliveries	No. of Months	Precise Value	Use	Cumulative Deliveries
1	1.000	1	1	16	4.1776	4	35
2	1.100	1	2	17	4.5954	5	40
3	1.210	1	3	18	5.0549	5	45
4	1.331	1	4	19	5.5604	6	51
5	1.4641	1	5	20	6.1164	6	57
6	1.6105	2	7	21	6.7280	7	64
7	1.7716	2	9	22	7.4028	7	71
8	1.9488	2	11	23	8.1409	8	79
9	2.1437	2	13	24	8.9550	9	88
10	2.3581	2	15	25	9.8505	10	98
11	2.5939	3	18	26	10.8356	11	109
12	2.8533	3	21	27	11.9192	12	121
13	3.1386	3	24	28	13.1111	13	134
14	3.4525	3	27	29	14.4222	14	148
15	3.7978	4	31	30	15.8644	16	164

EXHIBIT 2

A hypothetical acceleration rate and the resulting delivery schedule is shown and plotted in Exhibit 2. Actual monthly delivery schedules are plotted on semi-log grids for each of the five models and least square lines are fitted to the data, the slope of the line being the rate of acceleration for each model. For simplification in determining the rate of acceleration, a table was constructed from the formula so that the acceleration could be read directly from the table, knowing the cumulative quantity of airplanes delivered and the number of months of production required to meet this schedule. Such a table is shown, in part, in Exhibit 3. For example, a proposed delivery schedule which would produce a total of forty airplanes in seventeen months would represent a ten per cent rate of acceleration. (Follow arrows to circled figure on Exhibit.)

Formula for Basic Tooling

Because basic tooling is a function of the size and complexity of the airplane and the quantity to be produced, multiple regression equations were applied to factors of:

1. Weight as a measure of size.
2. Engineering hours as a measure of complexity.
3. Acceleration as a measure of rate of production.
4. Experimental tooling hours.

It became evident that experimental tooling hours had substantially the same effect in the formula as the combination of engineering hours and weight. A multiple regression equation was then developed, using experimental tooling and the rate of acceleration only. This resulted in a formula which proved to be more satisfactory, because the number of variables was reduced and correlation was improved. The relationship was also considered more reasonable by members of our department who follow tooling closely, and simplification of subsequent application was permitted. The formula follows:

$$\text{Basic tooling manhours} = 13.0 \text{ times experimental model tooling manhours} + 186{,}000 \text{ times } \% \text{ rate of acceleration}$$

For example, a production model having a proposed delivery schedule with ten per cent acceleration and a prototype which required 370,000 tooling manhours would require:

$$\begin{aligned} \text{Basic tooling manhours} &= (13.0)\ (370{,}000) + (186{,}000)\ (10) \\ &= 4{,}810{,}000 + 1{,}860{,}000 \\ &= 6{,}670{,}000 \text{ manhours} \end{aligned}$$

CUMULATIVE AIRPLANES DELIVERED
AT TIME PEAK RATE IS REACHED

Acceleration Rate	Months From 1st Delivery 6	7	8	9	16	17	18	19	20	21	28	29	30
0%	6	7	8	9	16	17	18	19	20	21	28	29	30
1	6	7	8	9	17	18	19	20	22	23	32	34	36
2	6	7	8	9	19	20	21	22	24	26	37	39	41
3	6	8	9	10	20	22	23	24	27	29	43	46	48
4	6	8	9	10	22	24	25	27	30	32	50	53	56
5	6	8	9	11	24	26	28	30	33	36	59	63	67
6	7	9	10	11	26	28	31	33	37	40	68	73	79
7	7	9	10	12	28	31	34	37	41	45	81	88	95
8	7	9	11	12	30	34	37	41	45	50	94	103	112
9	7	10	11	13	33	37	41	46	51	56	113	124	137
10	8	10	11	13	36	40	45	51	57	63	133	145	161
11	8	10	12	14	39	44	50	57	64	72	161	180	201
12	8	11	12	15	43	49	56	63	72	81	190	215	240
13	8	11	12	15	47	54	62	71	81	92	230	260	295
14	8	11	13	16	52	60	69	79	91	104	270	306	350
15	9	11	13	16	57	66	77	89	103	118	330	427	440
16	9	12	14	17	62	73	85	99	115	133	390	450	530
17	9	12	14	18	68	81	95	112	130	154	475	560	660
18	9	12	15	19	75	89	105	125	145	175	560	670	790
19	9	12	15	20	82	98	117	140	165	200	680	820	970
20	9	13	16	21	90	108	130	155	185	225	800	970	1150
21	10	13	16	21	99	110	145	175	211	255	925	1122	1350
22	10	13	17	22	108	132	160	195	238	285	1050	1275	1550
23	10	13	17	23	119	147	180	220	269	330	1300	1600	1950
24	10	14	18	24	130	162	200	245	300	375	1550	1925	2350
25	11	14	19	25	142	178	222	277	337	430	1875	2337	2875
26	11	15	20	26	155	195	245	310	375	480	2200	2750	3400

EXHIBIT 3

Exhibit 4 presents this solution graphically. Application of the formula to the data from which it was derived showed the following correlation:

Model	Tool hours for Experimental Model	% Rate of Acceleration	Basic tool hours for production model Calculated	Actual
A	1,105,085	9.1	16,058,705	16,053,000
B	218,091	25.4	7,559,583	7,687,000
C	298,000	17.7	7,166,200	7,200,000
D	268,000	4.3	4,283,800	4,403,000

Experimental Tooling

The curve shown in Exhibit 5 was developed to provide an estimate of the prototype tooling in the event that a prototype model has not been built. The curve is based on tooling manhours required for six different experimental airplanes and the airframe weight of the respective production models, because they provide a more stable weight index. A model having an airframe weight of 60,000 pounds would require 6.15 hours per pound of tooling for an experimental model, or (6.15) (60,000) = 369,000 hours.

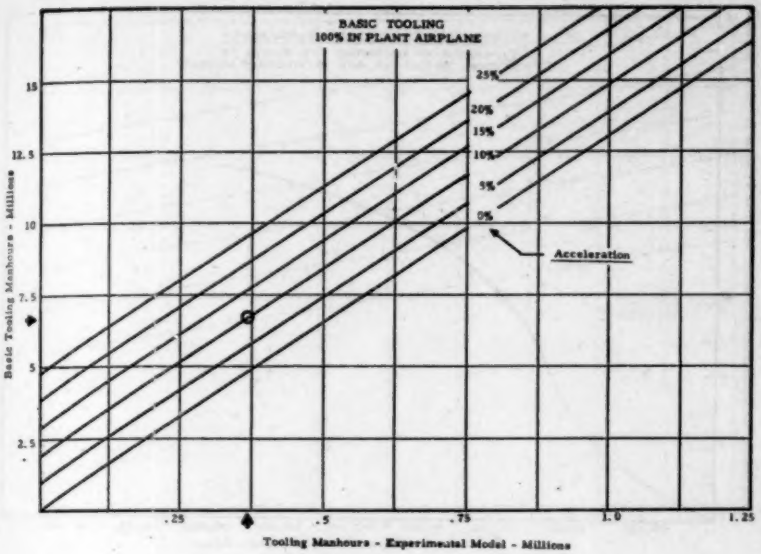


EXHIBIT 4

Formula for Sustaining Tooling

The sustaining tooling formula was derived by an approach similar to that used for basic tooling. Assuming the variance of the ratio of sustaining tooling to production labor to be a function of the size of the airplane and the rate of production, multiple regression equations were applied to combinations of weight, peak rate of delivery, average rate of delivery, and rate of acceleration of deliveries. The resulting correlation again indicated that the rate of acceleration gave the most reasonable measure of the relative rate of production. Combining weight and acceleration by means of multiple regression equations yielded the following formula for sustaining tooling:

$$\text{\% Sustaining tooling manhours to production labor manhours} = 5.58 + (.0322)\,(\text{AMPR Weight}) + (.308)\left[\frac{1000}{\text{(\% Rate of acceleration)}}\right]$$

Values for the above formula are shown in graphical form and in a table in the upper and lower halves, respectively of Exhibit 6. Because sustaining tooling is expressed as a per cent of production labor, any increases in production labor due to changes in model configuration would automatically carry the proportionate amount of tool labor indicated by the formula. Again, ap-

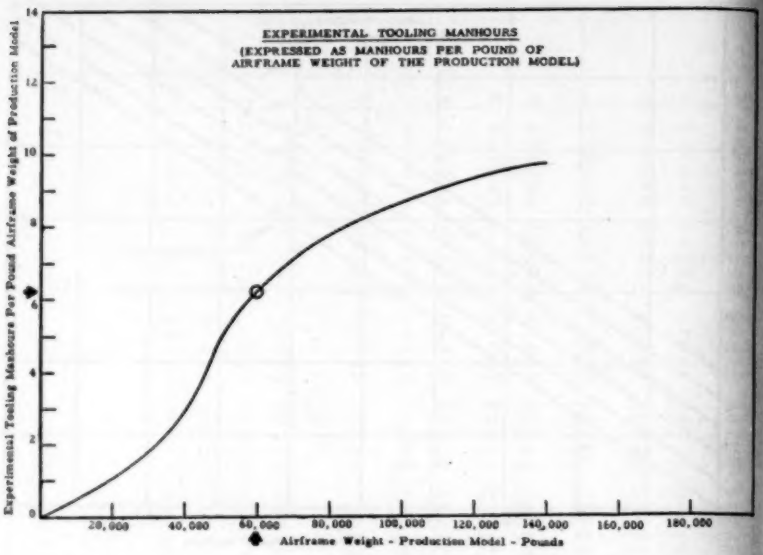


EXHIBIT 5

plication of this formula to the basic data from which it was derived shows satisfactory correlation:

Model	Airframe Weight	% Rate of Acceleration	% Sustaining tooling to production labor Calculated	Actual
B	48,000	25.4	14.9	15.0
C	55,000	17.7	12.8	12.7
D	57,000	4.3	8.7	8.8
E	22,000	11.1	9.7	9.7

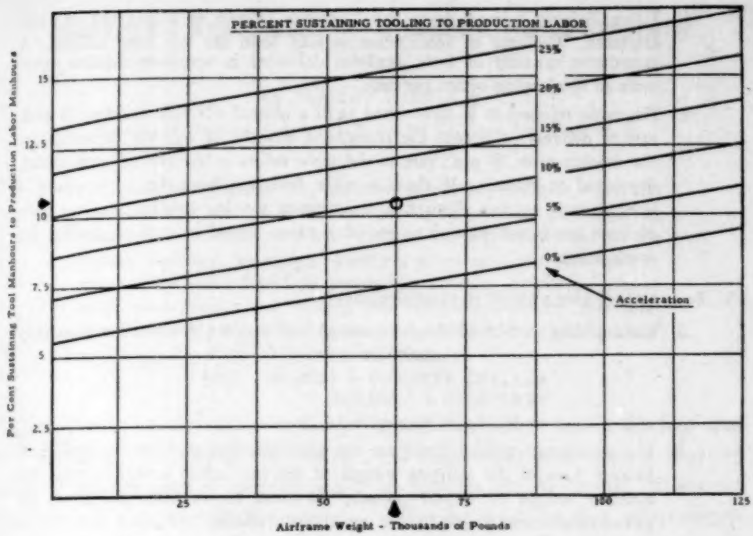
Solving a Sample Problem for Estimated Tooling Manhours

Steps for solution of a sample problem, in estimating manhours for tooling involving formulae which have been developed and the exhibits which have been given, are presented below:

1. Data Required:
   a. Airframe weight = 60,000 pounds
   b. Production labor (100% in-plant) = 15,000,000 manhours
   c. Delivery Schedule

Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
Planes per month	1	1	1	1	1	2	2	2	2	3	2	3	3	4	4	3	5	5	5	5
Cumulative	1	2	3	4	5	7	9	11	13	16	18	21	24	28	32	35	40	45	50	55

   d. Experimental model tooling (if available) = 370,000 manhours



DATA PLOTTED

(Tabulated From Sustaining Tooling Formula)

Rate of Acceleration	Airframe Weight Pounds	40,000	50,000	60,000	70,000	80,000	90,000	100,000	110,000	120,000
4%		8.1%	8.4%	8.7%	9.1%	9.4%	9.7%	10.0%	10.3%	10.6%
5		8.4	8.7	9.0	9.4	9.7	10.0	10.3	10.6	11.0
6		8.7	9.0	9.3	9.7	10 0	10.3	10.6	10.9	11.3
7		9.0	9.3	9.6	10.0	10.3	10.6	10.9	11.2	11.6
8		9.3	9.6	10.0	10.3	10.6	10.9	11.2	11.5	11.9
9		9.6	9.9	10.3	10.6	10.9	11.2	11.5	11.9	12.2
10 ◊		9.9	10.3	(10.6)	10.9	11 2	11.5	11.9	12.2	12.5
11		10.2	10.6	10.9	11.2	11 5	11.8	12.2	12.5	12.8
12		10.5	10.9	11.2	11.5	11 8	12.2	12.5	12.8	13.1
13		10.9	11.2	11.5	11.8	12.1	12.5	12.8	13.1	13.4
14		11.2	11.5	11.8	12.1	12.5	12.8	13.1	13.4	13.7
15		11.5	11 8	12.1	12.4	12 8	13.1	13.4	13.7	14.0
16		11.8	12.1	12.4	12.7	13.1	13.4	13.7	14.0	14.3
17		12.1	12.4	12.7	13.1	13.4	13.7	14.0	14.3	14.7
18		12.4	12.7	13.0	13.4	13 7	14.0	14.3	14.6	15.0
19		12.7	13.0	13.4	13.7	14.0	14.3	14.6	14.9	15.3
20		13.0	13.3	13.7	14 0	14.3	14.6	14.9	15.3	15.6
21		13.3	13.6	14.0	14.3	14.6	14.9	15.2	15.5	15.9
22		13.6	13.9	14.3	14.6	14.9	15.2	15.5	15.8	16.2
23		13.9	14.3	14.6	14.9	15.2	15.5	15.8	16.2	16.5
24		14.3	14.6	14.9	15.2	15.5	15.8	16.2	16.5	16.8
25		14.6	14.9	15.2	15.5	15.8	16.2	16.5	16.8	17.1

EXHIBIT 6

2. Rate of acceleration (%)
   a. From the delivery schedule, determine the number of months from delivery of the first airplane to the time peak rate is reached and the cumulative quantity of airplanes delivered at that time. Reading the data from Item 1c above gives the following:

      Peak rate of 5 airplanes per month reached in 17 months.
      Cumulative quantity of 40 airplanes delivered in 17 months.

b. Using Exhibit 3, read down the 17-month column to a quantity of forty airplanes. The rate of acceleration is read from the left hand column. A cumulative quantity of forty airplanes delivered in seventeen months represents an acceleration of ten per cent.

c. The table referred to is constructed to fit a normal schedule build-up to peak rate of delivery. Compare the cumulative quantity of airplane deliveries for the months prior to peak rate to the table values at the rate of acceleration, developed in pounds. If there is wide deviation from the table values, a line of least squares through a three-month moving average of shop completions per month plotted on semi-log paper should be used to develop the acceleration.

3. Basic tooling (for a 100% in-plant airplane)

a. Basic tooling = 13.0 (X-Model tooling) — 186,000 (% rate of acceleration)
manhours
= (13.0) (370,000) + (186,000) (10)
= 4,810,000 + 1,860,000
= 6,670,000 manhours

b. If experimental tooling hours are not available, they may be estimated from Exhibit 5, with the airframe weight of the production model known. For airframe weight of 60,000 pounds, the chart shows 6.15 tool hours per pound of airframe weight for the experimental model.

4. Per cent of sustaining tool manhours to production labor manhours through the time at which peak rate is reached.

a. Using the table at the bottom of Exhibit 6, read down the weight column (60,000 pounds) to the value opposite the acceleration (10%). The value from the table, 10.6% is the per cent of sustaining tool manhours to production labor hanhours.

b. Sustaining tool manhours = (10.6%) (Production labor manhours)
Sustaining tool manhours = (10.6%) (15,000,000 manhours)
Sustaining tool manhours = 1,590,000 manhours.

5. Basic tooling (3a) = 6,670,000 manhours
Sustaining tooling (4b) = 1,590,000 manhours
Total tooling 100% in-plant = 8,260,000 manhours
through time at which peak is reached.

Electronic Equipment — A Means, Not a Mystery

by ROBERT T. BRUCE

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To the author of this article, electronic accounting equipment does not introduce new principles to data processing as long performed by manual or mechanical methods. It introduces only new means for the sorting, collating, arranging, storing (recording), and summarizing processes—means which hold prospect of utilizing greater and greater detail more flexibly and reliably, and more economically. Identification of the manner in which electronic equipment "translates" manual procedures is a distinctive feature of this paper.

NOT MANY YEARS AGO — certainly within the memory of many of us —all of the processes of keeping business records were completely manual. Large ledgers were used to record accounting data. The only machines available were the adding machine and the typewriter. All source data was handled in detail by a staff of clerks who sorted, arranged, and recorded it, until the various entries were ready for the general ledger and balance sheets posting. Such functions as payroll, cost analysis and the like, which required detailed calculations on a unit record basis, were also handled manually. To reduce the burden of postings and account controls, bookkeeping machines were developed and, in the same era, tabulating systems or machine methods of accounting were introduced. Now we are offered electronic equipment for the same purposes. A detailed analysis of how any given application is processed on conventional tabulating equipment, as compared with electronic equipment would disclose that the same basic functions are required to produce the end result. The chief difference would be that, with conventional tabulating equipment, data is processed through different machines such as sorters to arrange cards, reproducers to create cards for other applications, collators to bring different decks of cards together under a controlled plan, and calculators to do the arithmetic required in any given procedure, whereas with electronic data processing equipment, such intermediate processing steps are quite often eliminated, the data arranging and calculation being accomplished completely within the confines of the machine. Electronics also permit the handling of data at a much greater rate of speed. There is an economic gain in the reduction in required personnel and the time required for processing.

This is a tantalizing prospect. What is the proper approach to it? As I see the situation, we can either be

hypnotized by it, skeptical of it, or face it realistically. I think it can be conceded that these three approaches reflect three different types of personalities and that the first two represent extremes which, if not modified will result in impulsive action or none at all. The middle ground is represented by the realist who requires the following characteristics to live up to that title.

1. He is aggressive, and at least looks at all areas of problem analysis without fear of being over-persuaded.
2. He can meet a problem head-on without flinching.
3. He is a severe, astute analyst, a logical thinker.
4. He has vision or the ability to take a current-day problem and evaluate it in terms of the future.
5. He is patient with progress as long as he is moving ahead on an orderly organized plan.
6. He evaluates a problem in terms of ultimate results and then sets up a program of orderly easy transition to obtain these results.
7. He evaluates a problem (at the start) in terms of economics and accomplishment without direct reference to particular persons places or things.
8. He investigates all possibilities and probabilities surrounding each problem and, based on a complete exposure to facts, determines the solution, the approach, and the progress involved to accomplish a given end.

If this is the approach to investigation of application of electronics, management is assured that any program will be set up on solid ground, that progress through programs will be controlled, and that the work the equipment is to perform is within its scope. A coordinated effort on the part of the manufacturer and the user of equipment is also assured.

Electronic Likened to Manual Procedure—And Differentiated

In pursuit of this realistic approach, we perhaps first want to know the work which can be assigned to electronic equipment. Such equipment is generally associated with mathematical processes. This association is natural because the first electronic machines were giant calculators or computers, high speed computation devices. Consequently, the term or name, computer has been made synonymous with all electronic devices. However, the equipment available today has, in addition to sections which perform arithmetic, capacity for storing large volumes of data and for sorting, collating, arranging, and summarizing it. Analysis of any office procedure, will disclose that it is made up of these same primary elements, together with a small amount of arithmetic. For example, manually prepared records such as payrolls, accounts payable invoices and accounts receivable invoices are received and sorted by class. They are then posted to control sheets or ledger sheets, so that they may be summarized for further postings. Extensions of invoices are checked by multiplying quantity times unit amount to verify gross amount. Discounts are established by a simple arithmetic process. By the proper collation of all entries final reports are constructed. The operations even if partly mechanized, require several posts or desks, each of which receives and processes data and

passes it on to another desk or machine. Each desk needs detailed instruction as to how to handle each piece of paper or document.

Electronic equipment does essentially the same thing. The basic differences are the speed with which data can be handled, the personnel required and the programming procedure. When you are operating a manual procedure, you have the power of decision with every employee, whereas, in an electronic system, you have a pre-planned pattern of operation with pre-determined criteria for decisions. Each piece of data must be analyzed for decision and processing instructions laid down which the machine will follow explicitly. This is a task but there are advantages included in it. When you give the power of decision in a manual operation to a clerk, you may have cause for concern not only for the reliability of the decision but for the consistency of the decision.

In evaluating the savings from use of electronic equipment an illustration of a recent survey on an application of payroll will be helpful. Under a manual procedure there was a clerical requirement of 18 persons (720 manhours weekly) to produce a 2,200 man payroll, complete with subsidiary reporting. We were advised that there was little tolerance in the allotted manpower. Under a semi-mechanized procedure using punched cards the payroll could be produced in 3 days or 24 hours, with a clerical force of 10 people (240 manhours). Under an electronic procedure the payroll could be produced in 7½ hours, with a clerical requirement of 3 individuals (24 manhours). Translating this into dollars gives the following comparison:

Manual procedure	
($2 per manhour)	$1,440.00
Semi-mechanized	
Clerical	$ 480.00
Machines ($10 per hour)	240.00
	$ 720.00
Electronic procedure	
Clerical	$ 48.00
Equipment ($30 per hour to reflect rental of $5,000 per month)	225.00
	$ 273.00

In summary, it can be stated that, while the unit hourly cost is high for electronic equipment, there is a definite indicated economic gain from the increased production speed together with the decrease in personnel. It is also true and important to point out that all general commercial paper work procedures are adaptable to electronic equipment and through its use, data can be made available for special analysis which, under previous methods, would be declared too expensive to obtain.

About Machine Sizes, Capacities and Operation

This discussion has not been directed to a particular style or size of equipment. I feel that the underlying

principles are identical, regardless of the style or size. The economic factor dictates the scope of the equipment which can be justified in a series of applications. The equipment manufacturers, until recently, have marketed equipment at both ends of the price scale. Electronic equipment is available at a monthly rental of $600 to $1,200 and the large scale equipment at a monthly rental figure of $18,000 and up. The equipment at the low end of the scale must be considered as auxiliary units to standard punched card equipment. Such units assist in increasing the speed of processing data and, in many instances, decrease some of the burdensome clerical duties. However, they cannot be considered data processing equipment from the overall procedural standpoint. On the other hand, the large electronic systems are designed to handle a completely integrated procedure, accepting the input data into the system, operating on this data completely within the confines of the equipment and producing directly from the equipment the final scheduled reports.

With this prefactory comment, it may be mentioned that the electronic equipment in my mind as I write is the Univac File Computer which has all the functions and versatility of the large-scale electronic equipment. From the economic viewpoint, it may be regarded as a medium size. Comparison of equipment on price and procedural abilities, is not complete without a comparison of speed. In comparing the speed of this computer with auxiliary electronic equipment, it can be said that it operates at a higher rate of speed. When compared with the large-scale electronic system, such as the big Univac, it is many times slower. It will be found generally speaking, that when the speed of operation increases, the cost increases.

Let us now take a look at the operation of this type of computer. By using this machine as a base, I can best illustrate what the manufacturer is doing for the user. First, let us consider the input and output devices. To provide an electronic system which can be integrated with any type of data processing, it must be capable of accepting source data in many forms. The various types of source data include conventional tabulating cards, paper tape (5-6-7-8 channel), magnetic tape, key punch (direct), and the typewriter. To increase the flexibilities of the input-output devices, the machine has been given the ability to read in with one type of input and read out on a different type of unit. For example, data may be read in from cards and read out to magnetic tape, and vice versa. There are no limitations in this area of function.

As to storage, there are two different forms available, i.e., magnetic drum storage and magnetic tape storage. Magnetic drum storage is avail-

able in two forms, low-volume fast access and high-volume slow access. The former has a capacity of 1,000 eleven character words, plus sign. The high volume drum storage has a capacity of 180,000 characters per unit drum, with a maximum of 10 drums in any given system. This would make the total storage capacity 1,800,000 characters.

With reference to access time, the low-volume fast access drum store has an average access rate of 2.5 milliseconds. The large volume drum store has an average access rate of 17.25 milliseconds. Magnetic tape storage capacity is determined by the length of tape available. One thousand two hundred characters can be stored in each foot of tape. On a 50 foot reel, 60,000 characters can be stored, 120,000 on 100 feet, and 180,000 on 150 feet. The access time to a specific piece of data is difficult to define, but the tape can be searched at a speed of 60 feet per second, with the reading and writing function taking place at a speed of 20 feet per second. In making a comparison of the magnetic drum storage versus magnetic tape storage, the time of locating data with drum storage is 17.25 milliseconds, whereas, with the magnetic tape, it is a question of location and distance to the next required piece of stored data. However, each medium has its use in application and, when combined, provides an effective operating tool.

Programming: Human Intelligence Into Machine Intelligence

As stated earlier, a paper handling procedure, whether manual, mechanical or electronic, requires the basic functions of data arranging, data summarization, and calculations as required. Random access to the drum storage, considered as a data arranging device and the magnetic tape storage, considered as a serial or sequence storage device—with the arithmetic unit to perform the calculations where required—covers the functional translation from a manual system to the electronic system. We have replaced each of the functions in the manually operated procedure with a like function in the electronic system.

To complete the picture, we must set up the machine intelligence and make the translation from the human intelligence to machine intelligence. In analyzing any manual procedure for criteria on which decision is based, it will be found that such criteria are always based on some type of coding system. Many companies have a highly developed coding system, a complete code of accounts against which all accounting entries are posted. Complete product codes, raw material codes, employee codes, etc, are included. In other companies, there are no methods of classifying operating data. Clerks determine the distribution or arranging of data by such criteria as an alphabetical description in the case of a commodity, a work center originat-

ing an entry, or the person signing an order, etc.

Machine intelligence, on the other hand, is based on a definitive coding structure. It is through a coding structure that a machine is caused to act. It is through a coding structure that a machine attains consistency of decision. With a definitive coding structure, you can operate on machine intelligence. Without it, you are obligated to operate on human intelligence in the particular area in which such intelligence is not open to inaccuracies and consistencies. It is from the coding system and procedure flow analysis that the instructions for the electronic system can be established. These instructions are generally called the program. The program contains the operating instruction to process the data from the input through the various processing steps to the final product.

It is the manufacturer's responsibility to design equipment which may be programmed by operating personnel. Many of the electronic equipments available today require the services of mathematicians or specialists to work out the machine programs. Equipment should be simplified to the degree that any individual who has complete operating knowledge of the procedure to be applied can prepare the program of instructions. In the Univac File Computer, the manufacturer has attempted to reach this level. There are only six basic commands which are required to operate the system. They are the four arithmetic commands — add, subtract, multiply and divide—and the two data processing commands—compare and transfer. With the two data processing commands operating in conjunction with the arithmetic commands as required any procedure can be applied.

Let us take an example and see how this technique is applied. In an accounts payable application, let us assume the requirements are to acquire the dollar value by vendor, to distribute the vendor amount by account charged, and to charge inventory, by commodity code, the quantity and amount of each item. Other features of the application are that the input to the application is punched cards, summary storage for vendors and inventory is on magnetic tape, and account summarization will be on punched cards to permit further distribution with other accounts and summaries. The commands "compare," "transfer" and "add" would be used with each detail input card. The detail cards, without sorting or arranging, would be processed and summarized on the magnetic drum. This operation would summarize them separately by vendor, by account charged, and by inventory code.

The "compare" command would select each of the three summaries to be made. The "transfer" command would move the balance to the adder for summarization. The "add" command would make the summarization. An-

other "transfer" command would return the summarized data to its original location. The control number, itself, would define the location of the data in drum storage. After the detail has been summarized in drum storage, account summary cards may be prepared by processing blank cards. By processing magnetic tapes for vendor balances and inventory code balances, these summary records may be updated. These three operations can be performed simultaneously within the same system. The techniques of application and programming are not difficult. Again, it may be said that the philosophy of the equipment is identical to that of a well-organized manual procedure or punched card procedure.

The Way of Progress

It seems to me that the equipment manufacturer's responsibilities extends to progress in new equipment and applications. The world is forever changing. The practices of today were mere fantasies of yesterday. The advances of the past decade suggest that we are living in the era of wonders. The product you see today is the result of research started three to five years ago. Tomorrow will bring more. Tomorrow you will have more of the same but better. In 1946 the best available in television sets was black and white with 10-inch screens. By 1951 we had black and white 21-inch screens. In 1952 and 1953 we heard talk of color. In 1955 we are still hearing about color. However, people in 1946 who delayed buying black and white television awaiting color and are still waiting have missed a lot of good entertainment. Likewise, companies which are waiting for something better in business electronic systems are going to lose a lot of solid economic gains.

There is, in any situation, a problem in economics which cannot be generalized in any summary. The best we can do here is to suggest that an application of electronic equipment is an integration of man and machine capabilities. This integration is intended to be economical but it is unlikely to be so unless the flow of data is straight-line in nature, completely streamlined, utilizing machine intelligence rather than human intelligence and unless the level of the detail recorded and maintained is such as to permit complete flexibility for comparative analysis purposes. If these conditions are met, the integration of man and machine efforts in an electronic installation is likely to be effective and takes the following form:

1. Man must develop the procedure.
2. Man must organize the procedure in a logical form representing that portion of human intelligence which can be converted to machine intelligence. Decisions which the machine can be programmed to make are among the important benefits. Man must integrate operations to attain full utilization of machine potentials, i.e., the machine must have application versatility within the economic limits that will support the application.

Given this situation, the machine can provide subsidiary reports in the form of statistical analyses which have been deemed too costly.

In short, human intelligence organizes the procedure for the application, programs it, and sets its objectives. Machine intelligence supplies speed, accuracy, and flexibility to an unprecedented degree, with the additional benefit of a limited range of programmed decisions. The machine is still just a tool to do man's work cheaper and more effectively. Man still holds the responsibility of application and the decision of what to accomplish and how it is to be accomplished. Men can think. The machine is still a robot and will operate only under the instructions of man, but he can go farther and faster with it, just as he can go farther and faster by auto than on horseback.

Organizational Effects of Electronic Equipment

by

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Taking the position that decentralization of operations and accounting may proceed pretty much as though nothing were happening in the data processing world (except for adaptations occasioned by use of a central data processing service for the company if the divisions cannot each afford an installation), the authors of this paper do see ahead to altered division of systems functions between the accountant and other staff, to some regrouping of personnel and detailed accounting functions, and to greater familiarity of the accountant with areas now collateral to his attention.

THE PROBABLE EFFECTS of electronic data processing on organization is a powerful stimulator for a theoretical or practical discussion. This article will outline certain viewpoints about the effects which electronic data processing machines may have on decentralized organizations and, more specifically, decentralized accounting organizations. We are experiencing the most amazing revolution in our business world and way of life. In addition to the power of atomic energy, we have the wizardry of electronics. Electronics for the office in the form of small and large electronic data processing machinery is a new challenge to the accountant. It is obvious that the interest shown by the business world in this new tool will quickly produce wide application of electronic computers and devices

to the processing of business data and problems.

To narrow the scope of the problem to be considered, we will limit comment to electronic data processing machinery of the large-scale variety, such as the International Business Machine's Type 705 and Remington Rand's UNIVAC. These machines rent for $20,000 to $50,000 per month. Procedural and programming work required to utilize this equipment is very time-consuming and, consequently, quite expensive. There are particular procedural features of electronic data processing equipment which should be mentioned at the start. As with punched card equipment (but to a greater degree), the more voluminous jobs can be more efficiently performed. Consequently, the bigger the job the greater the return. To achieve volume, uniformity of method may be required. When you think of volume and uniformity as related to organization, your first thought may be of centralization. Obviously, companies which have centralized management and/or centralized data processing departments are ideally situated from an organizational standpoint for the utilization of electronic data processing machinery.

If this is true, is the decentralized organization at a disadvantage? First let us define decentralization. A decentralized organization is one in which individual production units have full operating authority and responsibility within the framework of broad policies established by the central management. Or, briefly, such an organization has decentralized authority and responsibility with centralized control. There seems to be little reason for concluding that electronic data processing machinery, in itself, will offset the features of decentralization which have become attractive to so many companies in recent years. Why should it reverse the trend? Is it not just another machine method of processing data? Admittedly, it is fast, has memory, and other attributes, but what can such equipment do that many punched card machines and clerks cannot do? The answer is, "Nothing." It may perform the job faster and cheaper than another machine or a clerk, but it does not bear on the basic advantages of decentralization. Companies decentralize their organizations to obtain a free and concentrated management of a particular segment of the business. Decentralized management can devote all of its intelligence and judgment to the solution of problems of the particular unit. That stands as a fact, apart from office equipment considerations.

Effects of Centralized Data Processing on Decentralized Management

In short, any decentralized unit which can justify an electronic data process machine need not be affected organizationally. But the question is not completely answered. What about

the decentralized unit which is too small to justify this equipment? Should it be combined with one or more units of the company to permit electronic data processing? I do not feel a major reorganization of this type is necessary. I think the answer is to centralize data processing as such. In the light of this answer, let us consider whether or not centralized data processing detracts from the advantages of decentralized management. Management acts on the basis of facts, or on intuition or know-how if facts are lacking. If management can receive the facts it wants in the format it requires and at a time when the information is useful, the location and organizational position of the data processing department is unimportant.

The data processing department is a service organization supplying data about the business to be managed. Decentralized management can be served in two ways by a centralized data processing center. The first is the normal service of providing facts in the right quantity and at the right time. The second service is perhaps intangible but it represents the service rendered when responsibility for routine administrative operations is reduced and the manager (or managers) is thus provided with more time to attend to primary responsibilities. Does it really make any difference who prepares the payroll, who pays the bills or who collects the money? These activities are not at the heart of the responsibility of line management.

Earlier, it was pointed out that volume and the uniformity which promotes volume are desirable characteristics of electronic data processing applications. There may be a danger that a central data processing center may destroy its value to management by excessive uniformity. The special requirements and perhaps the eccentricities of decentralized management must not be overlooked in the mad scramble to save a clerical dollar. Yet decentralized management can be served better through the use of electronic data processing, because it can be provided with more information earlier. These significant benefits of timeliness and completeness of information must not be lost. If there is a need of liaison between the information center and the decentralized unit, it would probably be helpful to provide a small staff of analysts to co-ordinate the efforts of the center with the requirements of management. These analysts can digest and interpret the facts supplied to their management in the light of firsthand knowledge of special conditions in the division. If this is done, it seems to me reasonable to say that decentralized organizations and electronic data processing are compatible. The many benefits of the latter can be enjoyed by decentralized units by making the one relatively small organizational change indicated and that may not be

required in every instance. A central data processing unit can provide advantages to all units of a company. One further point may be made respecting the effect of electronic data processing, as centralized upon decentralized line management. The use of such processing for accounting is unlikely to have a significant effect on the product manager. In companies in which the costs of the center are billed to each of the products, the manager will have less control over those costs than he would have if the full accounting costs were under his responsibility but this should not be a sizable disadvantage, since the data processing costs will be less than the previous manual costs if the system is well conceived and applied. The product manager will continue the contact with his chief division accountant that he now has. He should not feel compelled to have direct contact with the manager of the data processing center, any more than he presently contacts central service departments which perform assignments for his chief accountant. There may be occasions when the product manager will be inconvenienced because his chief accountant does not have as rapid access to information in the center as he previously had when the accounting data was in his own department. This disadvantage should be more than offset by the more complete and improved reports which will now be available to the product manager. This is true, of course, only when the accountant has a good understanding of the system and is also familiar with the information contained in reports or otherwise available to him.

Impact of Electronic Data Processing on the Accounting System

The effect of electronic data processing on the accounting organization will vary considerably, depending on several factors. If it is used only to replace tabulating equipment, the changes should be relatively minor. The present supervisor will probably remain and no organizational changes appear warranted. This type of equipment change will not cause organizational revisions, even if the tabulating department performs work for several divisions, particularly if the applications are prepared by a staff reporting to the tabulating manager.

A factor tending to increase the organizational effect of electronic data processing machinery is its use to reduce clerical staff. The replacement of clerks for this reason generally indicates that considerably more systems work is required than is involved in merely replacing present tabulating equipment. When a substantial number of clerks is eliminated, it may also be possible to eliminate some lower level supervisors and to reduce the number of levels in the organization structure. In some cases, complete sections or departments will be eliminated. More frequently, however,

only parts of present-day departments will be removed. This will call for a re-examination of the remaining functions of these departments and a new determination of their status as separate departments. Combinations of the remainders of several small departments may be necessary to obtain large enough groups of employees to achieve sufficient flexibility. Companies requiring that several divisions cooperate in the use of a single electronic data processing center will face staff problems. This situation will probably require careful preparation of programs for the several accounting departments.

One of the methods of obtaining increased uniformity of procedure and volume of work in the electronic data processing center is to completely centralize (or recentralize) the various accounting departments. A less difficult and perhaps almost as effective means is to extract selected common functions from the several accounting departments and to establish a central processing department for each of these functions. For example, a central accounts payable department could be established to serve all of the general accounting departments. Other functions which could be centralized are payroll, accounts receivable, general supplies inventory and fixed asset control. These central departments may be possible only where the accounting departments being served are located in a limited geographical area, so that inter-communication is facilitated. There would probably be many problems in obtaining a workable relationship among the divisional accounting departments, the central clerical departments and the data processing center, but the advantages also appear substantial. The primary advantages in having functional centralization indicated are as follows:

1. The electronic data processing center will be dealing with only one department for each function centralized. This will enable it to process many more documents with one setup than would be the case if each accounting department submitted its source documents separately.
2. The documents received by the electronic data processing center will be prepared in a more uniform manner. This should increase the accuracy with which they will be keypunched and processed.
3. Centralization of a function increases the potential for obtaining improved productivity per employee and the flexibility of operation. These benefits may not be enjoyed in situations in which there would otherwise be a very small group performing a function.

In companies in which several decentralized accounting departments are to use a single electronic data processing system, there will probably be increased dependence on a central systems group. In order to reduce the cost of programming work (and the cost is substantial), many companies will use central programming staffs rather than have each decentralized unit prepare its own programs. The preparation of electronic data processing programs necessarily affects the functioning of remaining manual or mechanical systems and creates a re-

quirement for systems activity on these nonelectronic processes. The central systems group will, then, largely determine which operations are to be performed in the electronic data processing center and which are to remain manual or mechanical. It will also be instrumental in determining the form of the electronic data processing reports. In cases in which centralized clerical units have been established to service decentralized accounting departments, the central systems group will probably play a sizable role in determining the precise segregation of operations between the two types of departments. Further, in many decentralized companies, the systems in use in a division are primarily the division's responsibility. The central systems group is usually called in only on specific assignments. Under electronic data processing, this will apparently not be so and the factors mentioned above will cause a decided shift in systems responsibility from the decentralized divisions to the central systems group.

Changed Status for the Division Accountant, the Tabulating Unit

There will ultimately be significant changes in the division accountant's job. The use of electronic data processing will reduce the number of clerks under the accountant's supervision. This, in turn, will decrease the amount of time which he must spend in supervision and will increase the time which he can devote to other activities such as special cost studies, pricing policies and inventory control. The division accountant will probably lose part of his systems responsibility for reasons already discussed, but he will still be responsible for account classification, product costs, liaison with department heads and the product manager, inventory analysis and other related accounting functions.

The use of electronic data processing in applications other than accounting, such as production control, sales analysis, forecasting will broaden the accountant's contacts and familiarity with these areas. This will occur because the accountant's previous training with large volume data handling problems will make him a natural leader in this field. Consequently, other department heads will be likely to consult with him on their problems. All of the above changes should create a happy outlook for the industrial accountant. The increased opportunity to participate more completely in management decisions should come as a welcome relief from the more frequent day-to-day routine aspects of accounting.

The effect of electronic data processing on a central tabulating department will also be considerable. The assumption of responsibility for additional applications will make the tabulating department more important from a company standpoint and will make its effective administration

a matter of vital concern to the top management. In companies in which a single tabulating department serves several decentralized accounting units, the tabulating department is now usually able to process each division's requirements and each application separately. In this case, a knowledge of the overall accounting system is not required. This will be changed under electronic data processing accounting. A rather complete knowledge will be required of the relationship of each application to the others. Much more frequently than in the past the output of one application will be the input for another.

Organizational Planning Will Be At a Premium

It may be concluded in line with considerations developed here that electronic data processing machinery will have little effect on the organization of management in either centralized or decentralized companies. However, accounting and other data processing organizations may be significantly altered by the application of electronic data processing to their activities. Division accounting departments may be reduced in size, central clerical departments may be required, and the central tabulating department will absorb new and additional responsibilities with the installation of electronic data processing. An alert accountant considering the utilization of advanced equipment must first determine the organizational framework within which this new tool must function. This will exercise considerable influence over the type of electronic data processing equipment to be used and the scope of its application. Proper organizational planning will be of decided value in achieving the maximum benefits.

The Smaller Company Faces Electronics

by ROBERT L. LORIMER

Comptroller, Anderson-Bolling Manufacturing Co., Grand Haven, Michigan

It is the mission of this article to suggest that small companies need not be left out (or leave themselves out) of the prospect of adapting their accounting routines to automatic processing on machines, although such automation may come more slowly—and gradually—than in the case of larger companies. Mechanical devices now useful to small companies are identified and specifications for more complete installations are listed.

HIGH COST OF EQUIPMENT, threat of its early obsolescence, and lack of technical help make it easy for small companies to withstand the lure of "push-button" accounting. At the same time, being cognizant of their own limitations, managements of such companies look for ways of improving their control systems. Such improvements must come from ingenious rearranging of methods, using presently available equipment.

The chief limitation on substantially improving smaller company accounting this side of electronics is a lack of improved equipment. With few exceptions, office machines available on the market today are basically the same as offered on the market twenty years ago. However, this level of accounting methods is marked by a degree of mechanization. The development has been based largely on the following three devices:

1. Write-it-once methods, utilizing improved multi-copy business forms and "strips".
2. Improved posting machines.
3. More highly developed punch card methods.

These devices have contributed to mechanization of record-keeping but, as a substitute for electronic automation, they have serious limitations. For instance, the use of continuous multipart carbon forms (and of "strips" used in so-called "ledgerless accounting") has greatly reduced the number of times an accounting transaction is written, but such devices will not add, compute, or sort. The methods have no means of output and no memory. They are merely aids to manual accounting and are not basic beginnings of automatic accounting.

The current use of posting machines overcomes some of the limitations of manual duplicate-copy writing methods. Such devices will add and compute, but will not sort except through the pulling of a proper card and its manual insertion in the machine, or by use of a very limited number of fixed columns. The posting machine has no means of memory. Moreover, the use of the posting machines involves additional problems. In most applications the operator must

manually pick up previous balances, a burdensome manual process. Also, an error is printed on all copies of the record and is accumulated in the page totals. Posting machine manufacturers have perhaps added to the drawbacks of posting equipment in its application to smaller business by featuring numerical machines without an alphabetic keyboard and also without direct multiplication. Despite these drawbacks, posting machines appear to be the best present method of manually posting a record. However, it should be obvious that the use of a posting machine is an extension of manual methods.

The third mechanical device useful to the smaller company is punch card equipment. The machines will add, compute, sort, and compare, and they have a type of memory in that the cards provide automatic input for subsequent operations. Judged by automatic accounting standards, however, punch card methods have many limitations. Most installations do not provide a complete automatic accounting system but lend a degree of mechanization to individual accounting operations. The basic limitations in pre-electronic punch card accounting stem from the inability of the machines to classify at random (cards must generally be pre-sorted to obtain totals by classification) and the inability to remember. The use of punch cards involve other problems. Trained help is required. Part of the labor saved is offset by increased cost of filing an abundance of cards and tab sheets. For most smaller companies, the equipment is a poor posting device. Use of alphabetic information is limited, in that extended explanations of transactions (such as might be required on the purchase of fixed assets) are impractical.

Although the smaller company is thus in a discouraging position of waiting while its larger competitors develop automation in the office, its day will come. Already the managements of these companies have ideas as to what their automatic accounting system should be. The following are among the desired specifications:

1. The accounting system purchased should be complete. It should receive as input all transactions. It should provide as output all required accounting information. It should be both numeric and alphabetic.
2. The input should be simple and should be capable of receiving from a reasonable number of operators simultaneously.
3. Each item of input should be a simple debit and credit transaction. All thought of separate journals, such as sales journal, voucher register, payroll journal, should be dropped.
4. Equipment must have sufficient capacity to provide for general ledger accounts and for each detail item within each control account, including detail of accounts receivable, fixed asset accounts, accounts payable, payroll account, control expense accounts, cost of goods sold, and net income.
5. The equipment should be capable of retaining complete cost records, including the apportionment of service department costs to other departments, and automatically clearing variances as required.
6. The output should be such as would automatically prepare required business documents, such as accounts receivable statements, accounts payable lists, payroll checks and related records, expense

analyses, gross income by parts, by department, by customer and related categories, and complete financial statements.

7. The equipment should not be custom-made. All companies have simple debit and credit entries and most companies require approximately the same business records.
8. The equipment should be sold under a package plan. The vendor should provide technical assistance and training of company personnel in its operation.

In this early stage of the era of automation in accounting, managements of many companies may feel that automatic accounting is remote. However, a review of accounting practice would indicate that accounting mechanics are very simple—consisting almost entirely of classification, addition, and memory. These are tasks of which electronic equipment is capable. Realization of fully automatic accounting depends primarily on the application of presently known principles.

Letters to the Editor

PLANT "INTERCOM" HELPS SPEED DATA FOR DAILY CONTROL REPORTS

Editor, N.A.C.A. Bulletin:

ANY COST WHICH MANAGEMENT can control on a day-to-day basis should be handled for this purpose entirely apart from the cost system as a whole. Let us see how the usual plant "intercom" equipment will assist in getting interim reports on a daily basis, to help management's thinking and control labor costs before it is too late to do anything about them.

Common sense accounting for cost exceptions starts with the timekeepers, who, in this case, also act as dispatch clerks controlling the shop orders from the time they come into the shop until the parts are in stock. The timekeepers are in a room centrally located in the shop and are furnished with pre-written time tickets for each order issued and enough to cover each operation. The tickets are prepunched as to order number, part number, account charged and product code. Each timekeeper is assigned to particular departments and averages about seventy-five to one hundred men as a load. His equipment consists of a rack to hold time tickets, a punch clock to record the starting and stopping time on each job, a calculator, and an "intercom" box. The boxes are preferably placed on the foreman's desk within each department.

When an operator starts a job, he goes to the "intercom" box nearest him and calls his station, reporting something like this: Name, clock number, part number he is starting to work on and operation he will perform. The timekeeper picks up the time ticket, underscores the operation, repeats all the pertinent information to the operator and tells him the number of pieces he must produce an hour to make out. He then punches the operator in on the job. When the operator finishes the job, he reports in the same way and the timekeeper enters on the job ticket the pieces produced. While the timekeeper is waiting for others to call in, he extends time tickets. Indirect workers call in only at the end of the work period, just giving clock number and hours worked. The timekeeper selects the individual's time ticket and calls out all pertinent information, including clock number, job description, etc. Before the timekeeper leaves for the day, he checks his rack to see that all operators have eight hours of time and that all tickets are extended. Night timekeepers post the day time books from clock cards, post all direct labor tickets to proper orders, and post the new "balance to be done" on blank time tickets in the job rack, to avoid overruns and posting to wrong orders.

The next day, during slow periods, the timekeepers make out their reports to management. The first we will call a make-up time report, which is made as the tickets are being extended. If the operator does not "make out," his regular ticket bears incentive earnings only. Another ticket is made out for make-up pay to bring the total to guaranteed earnings. On this is entered the man's clock number, name, department number, part number, and operation number, pieces produced, actual hours, earned hours, piece work earnings, guaranteed earnings, amount of make-up pay and a blank space is left for remarks by the foreman. The ticket is made in duplicate. One copy is forwarded before noon to the superintendent's office and one copy to the foreman who puts down in the remarks column the reason for not "making out." The foreman then sends his copy to the

superintendent's office where it is acted upon quickly. A report is furnished standards department, for earnings over 130 per cent of standard, showing the same information as the make-up report except that it does not have the make-up pay column but, in its place, the efficiency per cent. The job is analyzed to see if all the factors of the original study are being followed.

Reporting on a day-to-day basis saves quite a sum of money, especially if the orders are large. The psychological effect these reports have on everyone concerned, including the plant manager, foreman, industrial engineer, and the operator, is amazing.

H. MYRON BOHN

BRUSHING UP ON MATHEMATICS

Editor, N.A.C.A. Bulletin:

AN INCREASINGLY LARGE NUMBER of articles in *The N.A.C.A. Bulletin* assume or recommend a basic understanding of mathematics and statistics. Most of them attempt to present their arguments in a format dealing primarily with simple algebra, but the inference is that such subjects can only provide an introduction to the subjects under consideration. The June 1955 *Bulletin* included two such articles: "Introduction to Model Building on Account Data," by Charles B. Allen, and "Using Statistical Tools to Set a Reject Allowance," by Edward H. Bowman. The first listed specifically mentions fields of mathematical study useful to a basic understanding. I would appreciate the advice of Mr. Allen relative to texts or references that would allow interested parties to self-educate themselves in the fields mentioned by him in his article. For some time I have felt that such a study is necessary for those of us who completed our mathematical education in high school. The whole tenor of Mr. Allen's article breathes a spirit of interest and concern that accountants should reach beyond that level. I have high hopes Mr. Allen will oblige with such a short list. Possibly such a short recommended bibliography would merit space in the *Bulletin*.

RODNEY LEE FORSETH

(The foregoing letter was referred to Mr. Allen, whose response is given below.)

Dear Mr. Forseth:

Your recent letter to the Editor of *The N.A.C.A. Bulletin* has been referred to me for reply. First, let me say that I am pleased that my article in the *Bulletin* evoked your interest. As for references, I might suggest Hogben's *Mathematics For The Million*, which is quite comprehensive but nevertheless fairly easy reading. There are numerous good high school algebra texts, such as *First Year Algebra* by Hawkes, Luby and Touton, *First Course in Algebra* by Wells and Hart, *First Course in Algebra* by Mallory, *Algebra* (Book I and II) by Aiken and Henderson (published by McGraw-Hill in 1954), *Fundamental Algebra with Practical Applications* by Robert Erickson (published by McGraw-Hill in 1949) and *Elements of Algebra* by Lyman Peck (published by McGraw-Hill in 1950).

There are two "standard" statistical texts, namely, *Applied General Statistics* by Croxton and Cowden, and *Statistical Methods* by Frederick Mills. You may also be interested in reading *Design for Decision* by Irwin Bross, published by The MacMillan Co., 1953.

I hope that this list will help you get started on acquiring additional mathematical and statistical facility. I will be happy to furnish a list of more advanced texts if you so desire.

CHARLES B. ALLEN

Notes on Current Reading

BOOKS

Accounting Trends and Techniques in Published Corporate Annual Reports (8th Edition)

American Institute of Accountants, 270 Madison Ave., New York 16, N. Y., 1954, 284 pp., $10.00.

Now a familar annual, the present edition of this "study conducted by the research department of the American Institute of Accountants, covering the accounting aspects of reports released annually by 600 industrial companies to their stockholders," relates to reports for "fiscal years ended between May 1, 1953 and April 30, 1954." Classified examples and indications of variations and trends in practice in financial statement presentation and in accountants' reports occupy its nearly 300 large-size pages.

Electronics in Business

Controllership Foundation, Inc., 2 Park Ave., New York 16, N. Y., July 1955, 176 pp., $2.00 to nonmembers, $1.50, members.

This enlargement of an annotated bibliography put out a year ago opens with a brief suggested reading list on its subject and then proceeds to detailed listing of material dealing with electronics in business, classified to periodical articles; proceedings, pamphlets and reports; books; company conferences, seminars and training programs; visual presentations, systems offered by the several principal manufacturers, descriptions of installations, and names of a number of commercial computing centers. The study is called a "descriptive reference guide."

College and University Business Administration—Volume II

The National Committee on the Preparation of a Manual on College and University Business Administration, American Council on Education, Washington, D. C., 1955, 267 pp., $4.50.

It was the function of Volume I (published in 1952) to deal with accounting, budgeting and auditing for educational institutions. The present volume concerns other business matters, among them purchasing, physical plant, insurance, management of auxiliary enterprise, investment management, administration of sponsored research and legal problems.

ARTICLES

Application of Electronic Digital Computers to Business Problems

Leslie M. Mannasmith, The Arthur Young Journal, July 1955.

There are brief examples in this article and, for each example, a diagram. Covered in this way are payroll, chain store accounting, utility billing and revenue accounting, inventory management, and insurance accounting applications. The equipment used is identified in each case. Other "future applications" are suggested at the close.

Controllership Motivation

James L. Peirce, The Controller, August 1955.

This is a somewhat personal article in that it deals with the controller's work and his attitude towards it. One sentence is, "controllership thrives on a diet of service motivation." A much later sentence is "Only the controller can afford to be completely objective." Between these two sentences is much readable material which goes beyond the duties of the controller to his application of himself to his work. The article is on the long side.

SELECTED ARTICLES FROM ACCOUNTING PERIODICALS

CANADIAL CHARTERED ACCOUNTANT, *September* 1955 (Chartered Accountants Building, 69 Bloor St. East, Toronto 5, Ontario, Canada, single copy $.50)

Flow Charting As a Technique in Business. W. D. Clarke

THE CONTROLLER, *August* 1955 (2 Park Avenue, New York 16, single copy $.50)

*Controllership Motivation. James L. Peirce.

A Variable Budget Installation for Control Purposes. Edward Shippen.

Productivity: Its Meaning—Its Measurement—Its Industrial Future. Allen W. Rucker.

The Controller's Interest in the World Calendar. Thomas M. McDade.

*A New Tool for Management: An Index to Managerial Efficiency. Weldon M. Padgett.

COST AND MANAGEMENT, *July-August* 1955 (31 Walnut Street South, Hamilton, Ontario, Canada, single copy $.50)

Organization As a Factor in Cost Reduction and Control. Gerald G. Frisch.

Budgeting and Long Range Forecasting. Thomas Chambers.

Month-End Closing—In Minimum Time Lapse. Members of Niagara Chapter, Society of Industrial and Cost Accountants of Canada.

JOURNAL OF ACCOUNTANCY, *September* 1955 (270 Madison Avenue, New York 16, N.Y., single copy $.75)

Accounting Reform in Washington. John W. McEachren.

The Intangible Drilling Deduction. Kenneth G. Miller.

The Auditor's Dilemmas in Cash-Basis Reporting. Harry B. Carlson.

Projecting Capital Needs. Richard M. Rothschild & Paul Kircher.

RETAIL CONTROL, *Summer* 1955 (100 West 31st Street, New York 1, N.Y., single copy $.75)

Productivity Standards in the Office. W. Robert Moore.

Recent Developments in Cost Accounting and the "Marginal Analysis"

James S. Earley, The Journal of Political Economy, June 1955.

Notice is taken in this article (primarily for the benefit of economists) that, while marginal analysis has been discounted substantially in economic thought, partly on the score of its substantial absence in business data, management accounting has been more and more introducing—and relying upon—such information objectively determined and is, as a technique, no longer "an impediment to profit maximization via marginal principles." The article is extended and somewhat detailed and requires to be read for its full import.

A New Tool for Management: An Index to Managerial Efficiency

Weldon M. Padgett, The Controller, August 1955.

A short presentation, this article is devoted to an "A to N" ratio for company units, representing ratio of "actual sales to sales necessary to break-even." The author states "comparison of N ratios of the various division managers is a very . . . valuable study. True, it is the trend rather than the exact comparisons that is important, and lateral comparisons must be made continuously."

SELECTED ARTICLES FROM BUSINESS PERIODICALS

ADVANCED MANAGEMENT, *July* 1955 (74 Fifth Avenue, New York 11, N.Y., single copy $.75 to members, $1.00 to nonmembers)

Financial Incentives: The Flywheel of Management Planning. Phil Carroll.
Maximum Product Value at Minimum Cost. C. Willard Bryant.

AMERICAN BUSINESS, *August* 1955 (4660 Ravenwood Avenue, Chicago 40, Illinois, Single copy $.35)

What About Profit Sharing? W. Irvin Brennan.
Even in Accounting There's Always Room to Improve.

CREDIT AND FINANCIAL MANAGEMENT, *September* 1955 (33 South Clark Street, Chicago 3, Illinois, single copy $.25)

Cash Forecast and Collection Budget Put Credit Management on Its Toes. L. W. Stolte.

HARVARD BUSINESS REVIEW, *July-August* 1955 (Soldiers Field Station, Boston 63, Massachusetts, single copy $1.50)

Decentralization and Intracompany Pricing. Joel Dean.
Key Questions in Pension Fund Investment. Willis D. Gradison, Jr.
The Strategy of Product Policy for Grown-Profits-Teamwork. Charles H. Kline.
How to Evaluate Automation. James B. Bright.

NATION'S BUSINESS, *August* 1955 (1615 H Street, N.W., Washington 6, D.C., single copy $.50)

Business Files Hold 1,200,000,000,000 Worthless Papers. Joseph P. Blank.

OFFICE EXECUTIVE, *August* 1955 (132 West Chelton Avenue, Philadelphia 44, Pennsylvania, single copy $.50)

Unit Invoice Accounting. E. A. Zickert.

The Decreasing-Charge Concept of Cost

Oscar S. Gellein, Journal of Accountancy, August 1955.

It is discernible that depreciation is at the center of this discussion, although other period costs may be involved. It is acknowledged at the start that American costing practice conventionally charges equal time periods with equal amounts of such costs. It is then pointed out—and given pro and con discussion—that income expectations from such costs may not conform to the pattern. A significant sentence is "Arguments favoring a decreasing charge concept are buttressed by the fact that, when business enjoys an advancing state of technology, obsolescence factors become more unpredictable." Sides are not taken by the author.

Operations Research — What It Is and What It Does

Robert A. Wofsey, Arthur Young Journal, July 1955.

That operations research is team study of problems of operations, usually centered on a model embodying the circumstances of the problem and permitting review of all combinations and variations of these circumstances is repeated in this paper, as in most introductory articles on this now-frequent subject. However, to add concreteness, there are given three cases in brief descriptive form. These relate to a problem of more effective use of coal mining facilities, whether a shoe company should convert its retail stores to an altered product mix, and minimization of freight charges in shipping to seventy warehouses.

For Your Information

Three Current Topics

THERE IS APPARENT in the accounting fields increasing attention to three topics. One is the processing of information on electronic equipment. The second is the use of sampling, frequency distributions, and other statistical concepts in interpreting information. The third is the application of model building (also a statistical concept) and the experimental approach in the solution of operational problems. This third topic involves familiarity with mathematics beyond arithmetic. Each of these three developments presents obstacles to most accountants, even if they seek to obtain only a working acquaintance. For such acquaintance, with respect to electronic data processing, it is necessary to improve focus upon the equipment itself. With respect to use of statistics, it is necessary to become mentally handy with its principal ideas, so that they are not just slick phrases but convey central meanings. With respect to operations research, a necessary preliminary to a working understanding is to add something of algebra, at least, to the individual's everyday mathematical equipment.

It is for these reasons that this month's "For Your Information" is devoted to three books (two of which have already received brief notice in the *Bulletin*), corresponding to the three topics. The expanded attention to these books here is little enough toward exposition of their contents and can only go a measured step or two beyond the description in "Notes on Current Reading." However, it is felt, that a further disclosure of contents may help readers to judge of the applicabality of these works to the three topics which have been identified. The books are:

Data Processing by Electronics
Haskins & Sells, 1955, 113 pp.

Managerial Statistics
Kermit O. Hanson, Prentice-Hall, 1955, 306 pp.

Business Mathematics
Walter F. Cassidy and C. Carl Robusto, Prentice-Hall, 1952, 109 pp.

Data Processing by Electronics

The proportionate space given to the several principal aspects of the subject in the Haskins and Sells volume on *Data Processing by Electronics*, which aims "to convey to the interested reader . . . a basic understanding of the operation and use of electronic data-processing systems," is indicated in its table of contents as follows:

	Number of pages
"A general description of electronic data—processing systems and the factors involved in considering their use"	22
"Basic theory, systems components, and techniques in application"	36
"Operating characteristics and costs of various (makes and models of) data-processing equipment"	46

The general description of electronic data processing is tackled through the subtopics, "a comparison of methods," "the scope of electronic data processing," "fundamentals of programming," and "preparing for the electronic system." Consideration of theory, equipment components and techniques involves as subtopics, "basic concepts," "components," "an illustration of programming," and "an accounting application." The section of the book dealing with the characteristics of particular equipment is identified as an appendix and compactly describes eleven systems of nine manufacturers, devoting several pages to each system. This part of the book has (on page 67) its own table of contents.

Under the caption of "The scope of electronic data processing" (among those cited above) is given in two and one-half pages a summary of operation of an electronic system and auxiliary nonelectronic features currently needed. A portion of the text is as follows:

> "The heart of the electronic data-processing system is the central processing unit, often called the computer. The processing unit consists of a control unit, a storage device and an arithmetic unit. The control unit interprets instructions and directs the various data-processing operations. The storage device, or 'memory,' receives the instructions and data from the input device, stores intermediate results, and releases information, all as directed by the control unit. The arithmetic unit performs the arithmetic and comparison operations upon data and instructions routed from the storage device, again as directed by the control unit. . . .
>
> "Directly linked electrically to the processing unit are devices which 'read' information into it and 'write' information out of it. . . . Inbound information fed into the 'reading' device must be expressed in, or converted into, the symbolism of the processing unit. . . . To do this necessitates the use of input preparation equipment and output printing equipment.
>
> "Some of the input preparation equipment may be electronic in principle but at least part of it always is not. . . . There is a tendency to visualize the electronic system as one that handles all steps in the data-processing routine. This is a misconception. . . . Nevertheless, the electronic phases of processing encompass a vast area. Moreover, the challenge to overcome the limitations of input preparation equipment has met strong response. . . ."

Managerial Statistics

The textbook by Mr. Hanson on *Managerial Statistics* is not solely a treatment of statistical concepts, although description of them is to be found there. In position, the matter perhaps most needed by the nonstatistician occupies the center of the book, preceded by material on sources of statistical data within and without the business and why such data are useful, and is succeeded by application and illustration in forecasting and control uses, i.e., report preparation and reporting of data on sound statistical bases. Hence, the text is thoroughly relevant to industrial accountants from start to finish but, if the central chapters were passed too lightly over, could possibly be perused fairly attentively without imparting as much as could be desirable about statistical concepts and methods.

These central chapters are, primarily, chapter 3 on "collection of data by sampling," Chapter 4, "Statistical techniques: frequency distribution and averages," and Chapter 5, "Statistical techniques: measures of variation and skewness." The chapters on techniques might also be considered to include the succeeding three chapters on respectively, "analysis of general business conditions," "forecasting sales: time series analysis" and "forecasting sales: correlation analysis." Although this latter group of chapters also concerns application of techniques, it remains concerned likewise with their introduction to the reader and their development in his understanding.

The chapters on sampling, frequency distribution, averages and measures of variation and skewness occupy sixty pages (pp. 26-85). Through it are scattered those introductory sentences about underlying concepts, with which accountants have become vaguely familiar without passing beyond. In this volume, they can do so. Below are some of the known starting points:

> "Sampling is the process of collecting and analyzing a few data for the purpose of obtaining information about a large quantity of data" (page 26).
>
> "Arrangements of homogenous data by classes are referred to as frequency distributions; these distributions show the frequency with which data occur in each class" (page 44).
>
> "Averages are referred to as measures of central tendency because they are designed to measure central values around which data tend to cluster" (page 51).
>
> "Also required are measures of varia-

tion, that is, dispersion, deviation, spread, or scatter of the data around the measures of central tendency" (page 68).

More Mathematics

Of the three works being considered here, that by Messrs. Cassidy and Robusto is least new, having been issued in 1952. However, similarly, their subject matter is last dependent on time. In fact, the title *Business Mathematics* reflects dependence upon time only to the extent that mathematics selected as of interest to businessmen and industrial accountants is influenced by current developments. Perhaps this is the reason why it may be necessary to select relevant chapters for attention. There are otherwise useful chapters on cash and trade discounts, bank discount, real estate, amortization and sinking funds, valuation of bonds, and life insurance and life annuities, which are not directly helpful to the individual seeking missing mathematical links to the use of formulas modeling operating situations, in line with emphases of operations research.

However, there are other chapters readier to this need. A review of calculations considered arithmetic is given in Chapter I which is followed by chapters on "algebraic calculations," "exponents and logarithms," and "percentage." Chapter VI deals with "simple interest," Chapter VIII with "profit and loss," Chapter XI with "averages," and Chapter XVI with "depreciation and capitalized cost." In other words, although the book is rather clearly angled toward the idea that the accountant is concerned with mathematics needed for financial analysis, it does include chapters on mathematical subjects, the substance of which is needed for understanding of the techniques of operational analysis.

The chapter on "algebraic calculations" reminds the reader that "algebra is an extension of the study of arithmetic in which numbers are represented by letters of the alphabet which may have numerical values assigned to them." The headings within the chapter are:

- Algebraic addition
- Algebraic subtraction
- Parentheses
- Exponents
- Multiplicaton of polynomials
- Division of polynomials
- Types of equations
- Solution of first degree equations
- Special products
- Factoring
- Quadratic equations
- Solution of quadratic equation by formula
- Arithmetic progressions
- Geometric progression
- Binomial theorem

Intention of These Notes

There is no pretense, in the foregoing paragraphs, of either complete or authoritative comments on any of the three books dealt with, nor a definition of their relationship to today's concerns of industrial accountants. The thought has been, rather, that these notes together in this place would serve to emphasize a new importance to accountants possessed by the topics of electronics, statistics and mathematics and a recollection of some of their terms and major divisions in subject matter. It is quite likely that accounting literature of the future will contain article and book contributions to these areas and that accountants will benefit by being on the watch for them.